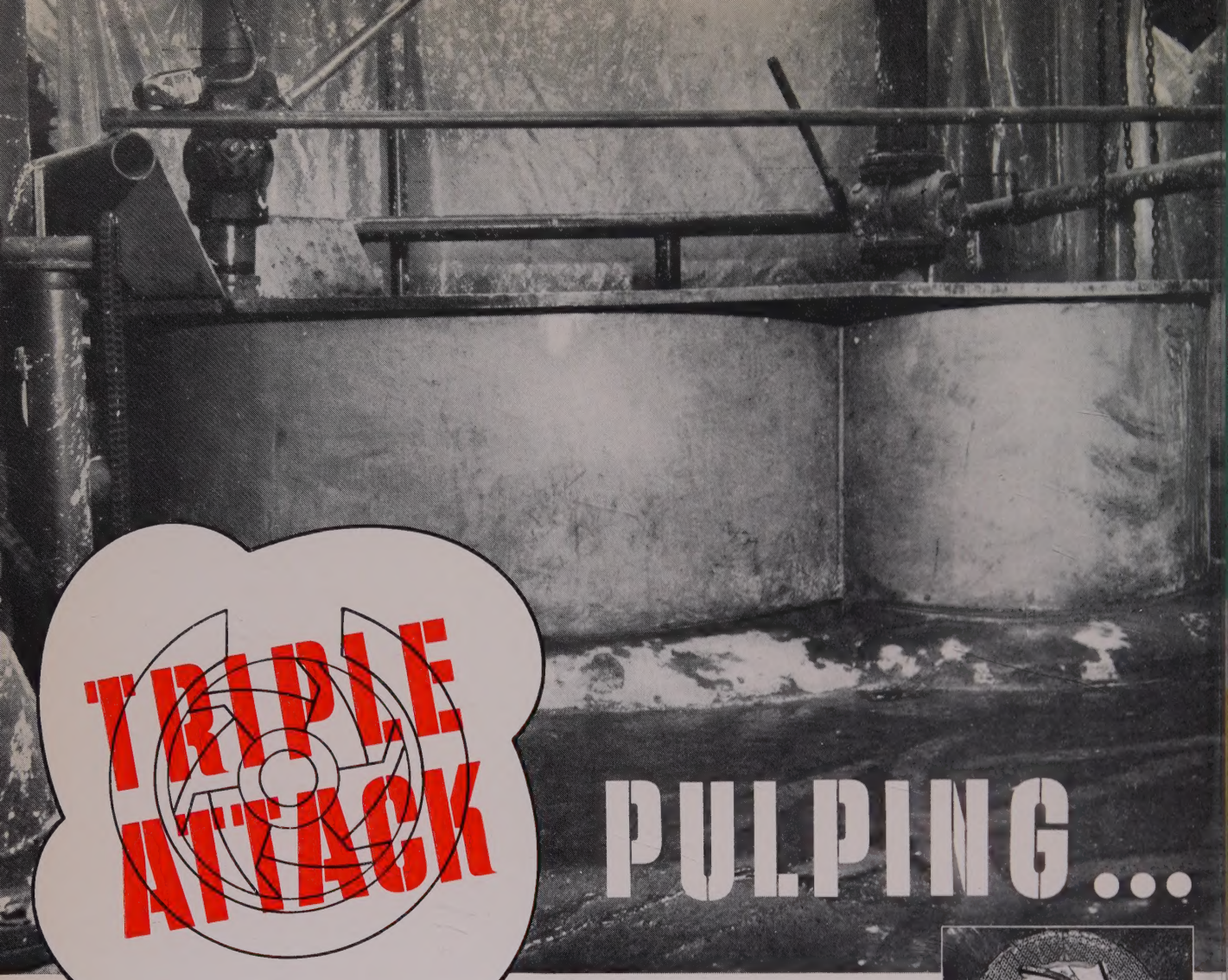
Tappi

HE JOURNAL OF THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

MARCH 1960

VOLUME 43 • NUMBER 3



TRIPLE ATTACK PULPING...

what makes this new method so successful?

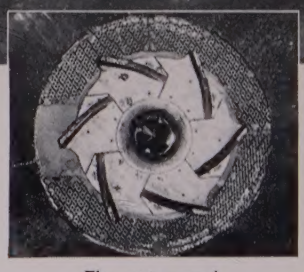
Triple Attack pulping is an advanced method, exclusive in the new Emerson Pulper, that *multiplies the number of defibering cycles which take place within a given period.* Thus, it guarantees maximum defibering on all types of stock — in 20 to 30 minutes — wet strength slightly longer. It also offers complete pulping at 8 to 12% consistency, uniform mixing, fast charging and dumping, and extremely low power consumption at full or partial capacity.

The success of the Emerson Triple Attack Pulper lies in its advanced lobe shape, tapering tub walls, conical bottom and effective impellor action.

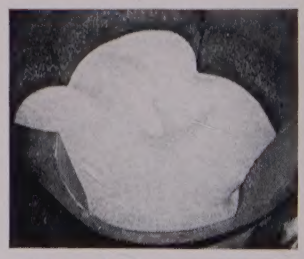
Pulp fibers are subjected to a relentless triple attack by (1) the violent agitation of the impellor, by (2) the force and friction of fiber contact with the specially designed tub walls, and by (3) the vigorous hydraulic defibering action caused when on-coming stock streams from the impellor hit the flow of stock returned by the tub walls.

Because of this exclusive tapered and lobed wall construction, all "dead spots" are eliminated. Triple Attack pulping provides complete defibering by the fastest, most economical method yet devised.

For further information, please write to The Emerson Manufacturing Co., Division of John W. Bolton & Sons, Inc., Lawrence, Massachusetts.



The rotor and extraction plate



View of vortex and stock flow at 8-9% consistency

Emerson TRIPLE ATTACK **PULPER**

A product of BOLTON EMERSON

SHELF TALKER—Alpha® Protein takes the cake at selling it!

The best-selling foods on super-market shelves are those that clamor for attention . . . tempt the shopper by creating the taste-treat right on the package.

How to achieve this full-blown realism on competitively produced coated paperboard? Use Alpha Protein, the chemically isolated soy protein binder. It improves whiteness and brightness, gives the smooth uniform surface needed for fine-screen halftones.

With Alpha Protein in the coating formulation higher solids can be attained, resulting in higher production speeds at reduced costs.

For the newer trailing blade coater, Chemurgy Division offers its Chem-Pro, a specially modified soy protein binder that provides even higher solids.

Chemurgy Division, pioneer in protein coating adhesives, can assure you a uniform high-quality product . . . adequate, on-time shipments . . . stabilized price . . . on-the-spot technical service.

25
YEARS OF CHEMURGY EXPERIENCE

CENTRAL SOYA COMPANY, INC.
CHEMURGY DIVISION
1825 N. Laramie Avenue · Chicago 39, Illinois

This is a sample of 4-color process lithography on Alpha Protein-processed paper

* Idea submitted by John Ramsey, Asst. Production Mgr., The Champion Paper and Fibre Company, Hamilton, Ohio

Photo by: H. Armstrong Roberts

"Paper rolling over HAMILTON Felts reminds me of 'money in the bank!'"

YOU CAN'T BEAT

Hamilton

FELTS

"Every time I see paper
rolling over Hamilton Felts,"
writes John Ramsey, paper-
maker, of Hamilton, Ohio,
"it reminds me of money—
money being saved for the papermaker."

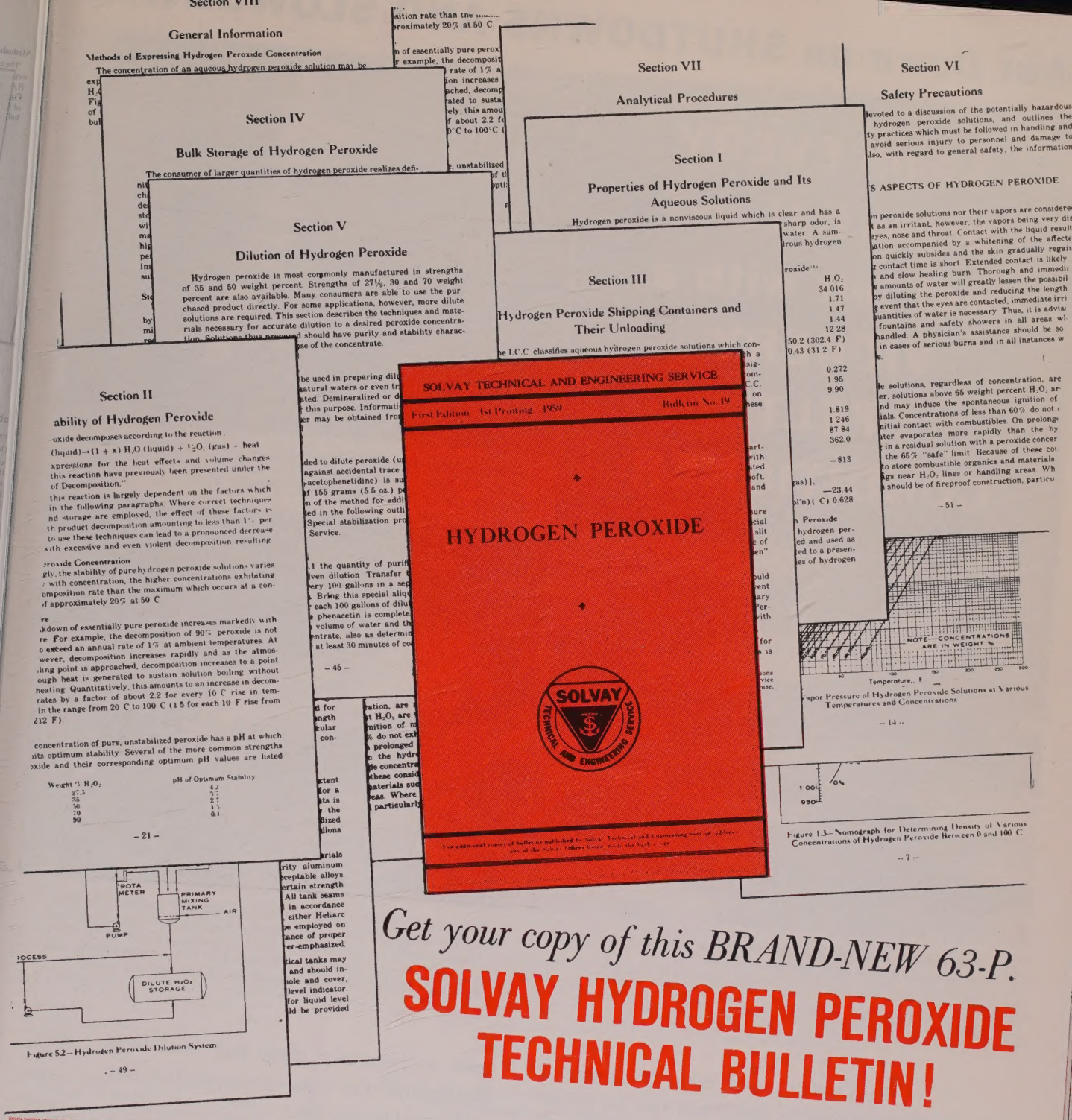
The long service
and high quality performance
you get from Hamilton Felts
means money in the bank.
Hamilton Felts help you beat
the high cost of downtime
by keeping your machines running
at top speed . . . longer . . .
turning out more tonnage
with less broke or imperfections.

Ask your Hamilton Felts Service Salesman
how long-lasting Hamilton Felts
can help you reduce
the high cost of downtime . . .
or write us—today.

* WIN . . . *A NEW Spincast Fishing Outfit*

"What famous landmark reminds you of Hamilton Felts? Tell us why in a few words; sign your name and address and name of company. The best letter each month by a papermaker wins a new 1960 model Shakespeare Spincast Rod and Reel — FREE ! Every papermaker entrant receives a famous Rex Spoon fishing lure — FREE. Send me your suggestion — today. Ham Feltz, 612 First National Bank Bldg., Cincinnati 2, Ohio."

SHULER & BENNINGHOFEN, HAMILTON, OHIO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Methods of Expressing Hydrogen Peroxide Concentration
Section IV
Bulk Storage of Hydrogen Peroxide
Section V
Dilution of Hydrogen Peroxide
Hydrogen peroxide is most commonly manufactured in strengths of 35 and 50 weight percent. Strengths of 27½, 30 and 70 weight percent are also available. Many consumers are able to use the pur chased product directly. For some applications, however, more dilute solutions are required. This section describes the techniques and mate rials necessary for accurate dilution to a desired peroxide concentra tion. Solutions thus prepared should have purity and stability charac
Section VII
Analytical Procedures
Section I
Properties of Hydrogen Peroxide and Its Aqueous Solutions
Hydrogen peroxide is a nonviscous liquid which is clear and has a
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ability of Hydrogen Peroxide
SOLVAY TECHNICAL AND ENGINEERING SERVICE
First Edition 1st Printing 1959 Bulletin No. 19
HYDROGEN PEROXIDE
SOLVAY
TECHNICAL AND ENGINEERING SERVICE
Figure 5.2—Hydrogen Peroxide Dilution System
Figure 1.3—Nomograph for Determining Density of Various Concentrations of Hydrogen Peroxide Between 0 and 100 C
Vapor Pressure of Hydrogen Peroxide Solutions at Various Temperatures and Concentrations

Get your copy of this BRAND-NEW 63-P.

SOLVAY HYDROGEN PEROXIDE TECHNICAL BULLETIN!

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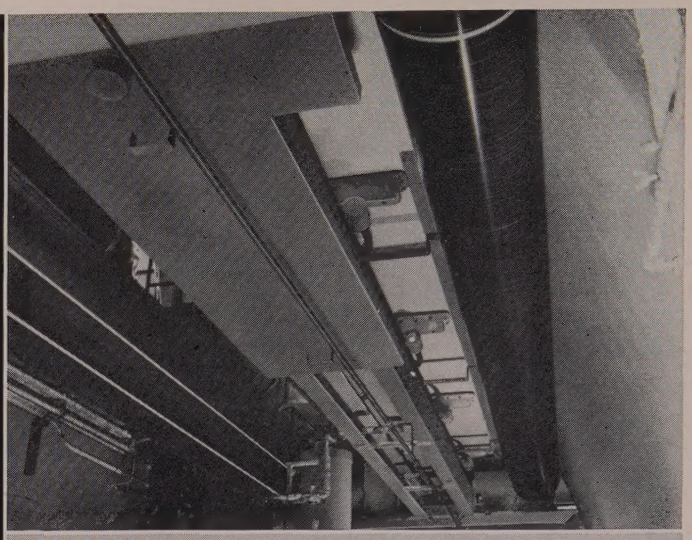
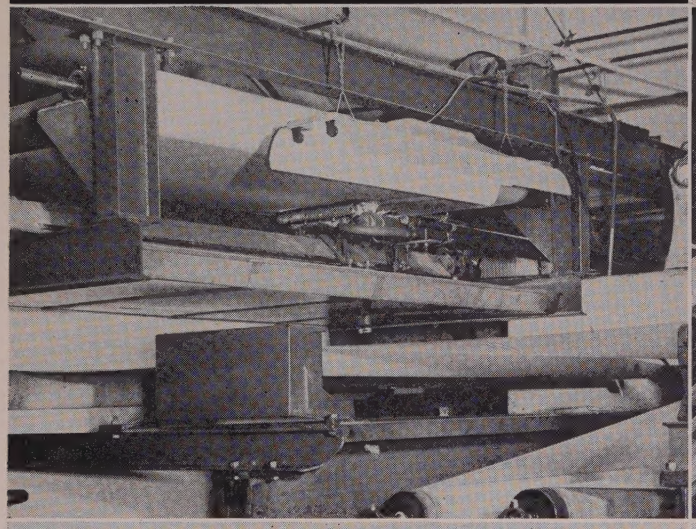
City _____ Zone _____ State _____ BN-89

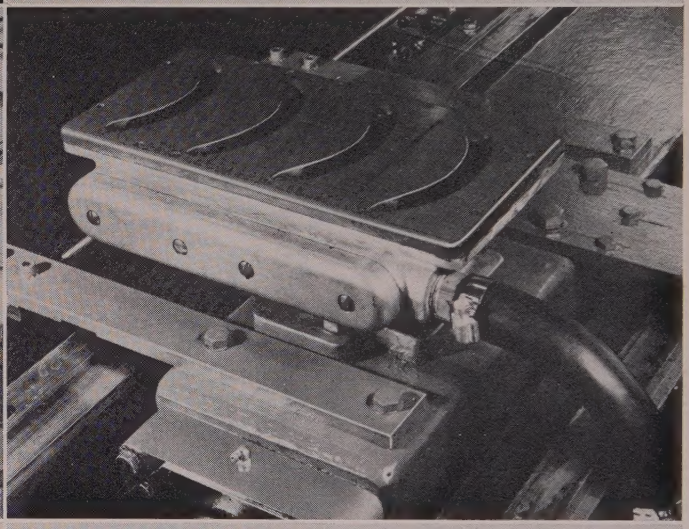
Equip EVERY press felt and wet felt with a VICKERY FELT CONDITIONER



This Vickery Conditioner with four conditioning boxes on a big, high speed book machine felt is of the new, self-contained traveling header design. It is equipped with hydraulic drive.



This Vickery Conditioner on a machine making top grade writings is saving *two or three shutdowns a week.*



Vickery Wet Felt Conditioners are doing an equally effective, money-saving job of reducing cylinder machine shutdowns. Top and bottom felts are continuously clean and open. Crushing is often avoided. Shower volume is minimized. Felt life is often greatly increased. Machine speed is maintained right through the week.

With today's production demands and high operating costs, you can no longer afford mid-week shutdowns for felt wash-ups. And taking the weights off the presses and slowing down toward the end of the run is likewise too costly.

Vickery Felt Conditioners keep the felts continuously clean and absorbent throughout the run, whatever the size and speed of the felt.

Don't let a single felt go dirty. Investment in Conditioners never produced such handsome returns as it does now!

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SOUTH WALPOLE, MASS.

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Canadian Manufacturers of Bird Machinery
CANADIAN INGERSOLL-RAND COMPANY, Limited, Montreal

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Calendar of National Conferences

Eleventh Coating Conference
Edgewater Beach Hotel, Chicago, Ill.
May 23–25, 1960.

pulp Bleaching Conference
Edgewater Beach Hotel, Chicago, Ill.
June 14–16, 1960.

Fourteenth Alkaline Pulping Conference
Multnomah Hotel, Portland, Ore.
Aug. 22–24, 1960.

Forest Biology Conference
Seattle, Wash.
Aug. 24–27, 1960.

Eleventh Testing Conference
Pantlind Hotel, Grand Rapids, Mich.
Sept. 27–29, 1960.

Tenth Corrugated Containers Conference
Royal York Hotel, Toronto, Canada
Oct. 10–13, 1960.

Fifteenth Plastics-Paper Conference
Hotel Syracuse, Syracuse, N. Y.
Oct. 17–19, 1960.

Fifteenth Engineering Conference
Robert Meyer Hotel, Jacksonville, Fla.
Oct. 24–28, 1960.

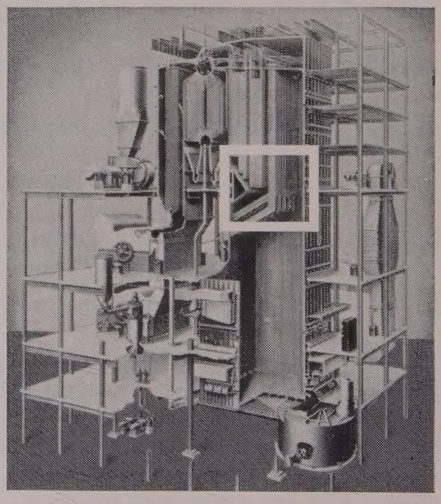
Please refer to Local Section Activities for the locations and dates of Section meetings

In the new C-E recovery units . . .

Tangent tube "panels" shed slag, add to ease of operation

Each panel in the superheater and furnace screen of the new C-E Recovery Units is a *solid wall* of tubes tangent to each other, with generous spacing between panels. The continuous panel surfaces shed much of the slag as it forms, the remainder being easily dislodged by soot blowers.

This "self-cleaning" C-E design permits smooth, unimpeded gas flow and minimizes slag build-up. Heat absorption is uniform across the width of the furnace. Soot blower effectiveness is increased and surfaces remain cleaner — resulting in important operating economies.



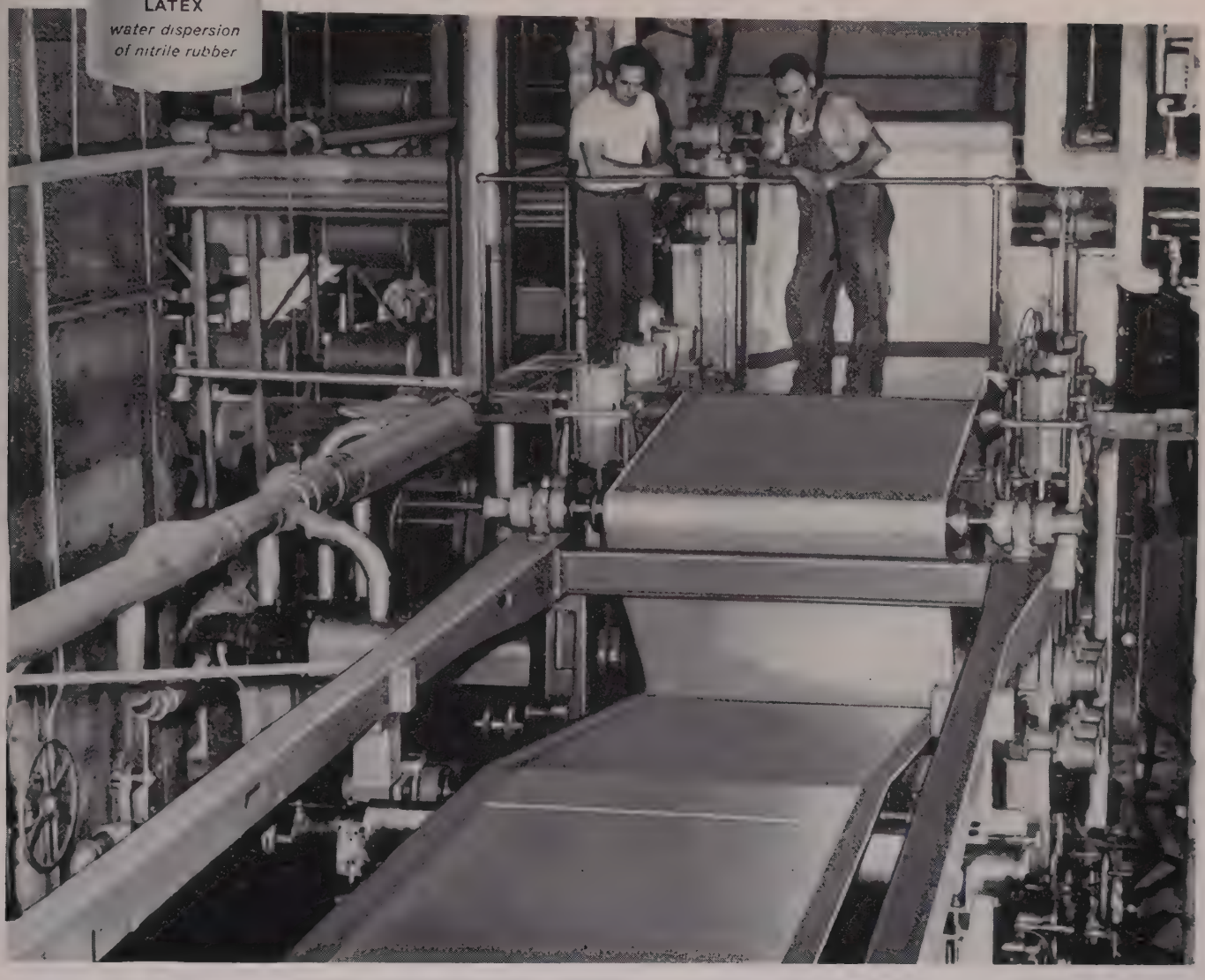
Superheater of the C-E Recovery Unit, as shown here, is located directly over the furnace so that slag falls to the hearth. A section of illustration has been enlarged to show widely-spaced panel construction of superheater and furnace screen.

COMBUSTION ENGINEERING

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.
Canada: Combustion Engineering-Superheater Ltd.

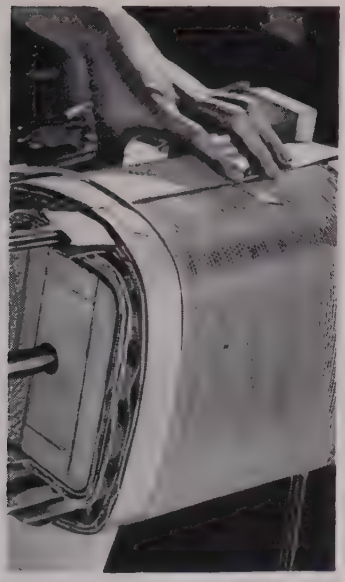
C-252

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE



—as used to make better dielectric sheet at Johns-Manville, New York, N. Y.

How to transform a problem-product into a profit-maker—with CHEMIGUM LATEX



The problem was the standard-saturated asbestos dielectric sheet for transformers. It insulated well, but the solvents of one manufacturer's varnish system were not compatible with the saturant in the paper.

The answer was to replace the standard resins with CHEMIGUM LATEX. Incorporated by single-step beater addition rather than multipass saturation, CHEMIGUM LATEX not only fully resisted the solvent attack, but also lowered costs. Moreover, it did so with no sacrifice in strength, moisture-resistance, heat-resistance or handling characteristics.

How can CHEMIGUM LATEX help you turn problems into profits? For full details, including the latest *Tech Book Bulletins,* write Goodyear, Chemical Division, Dept.O-9432, Akron 16, Ohio.

GOODYEAR

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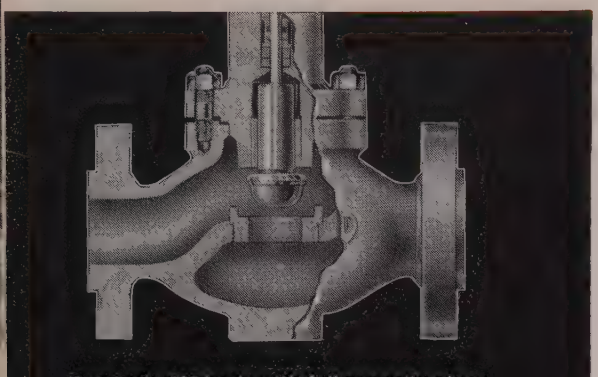
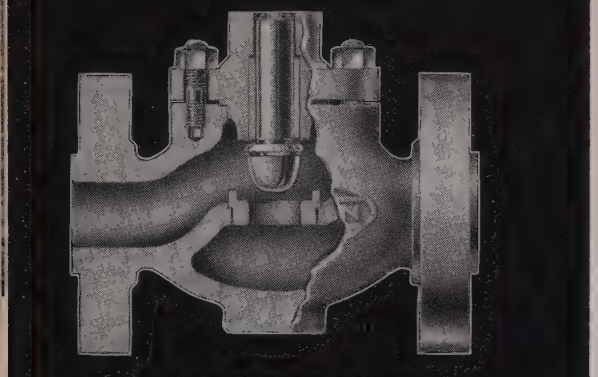
Chemigum—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

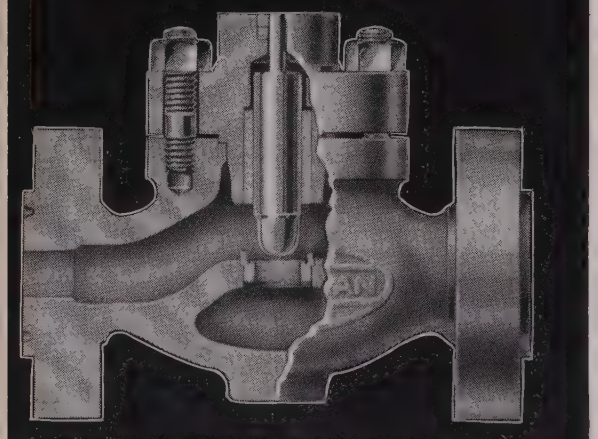
Masoneilan 20000 Series Control Valve



Two inch, 600 body with full capacity plug.



Two inch, 1500 body with full capacity plug.



Two inch, 2500 body with full capacity plug.

The Most Versatile Single Seated Valves Available

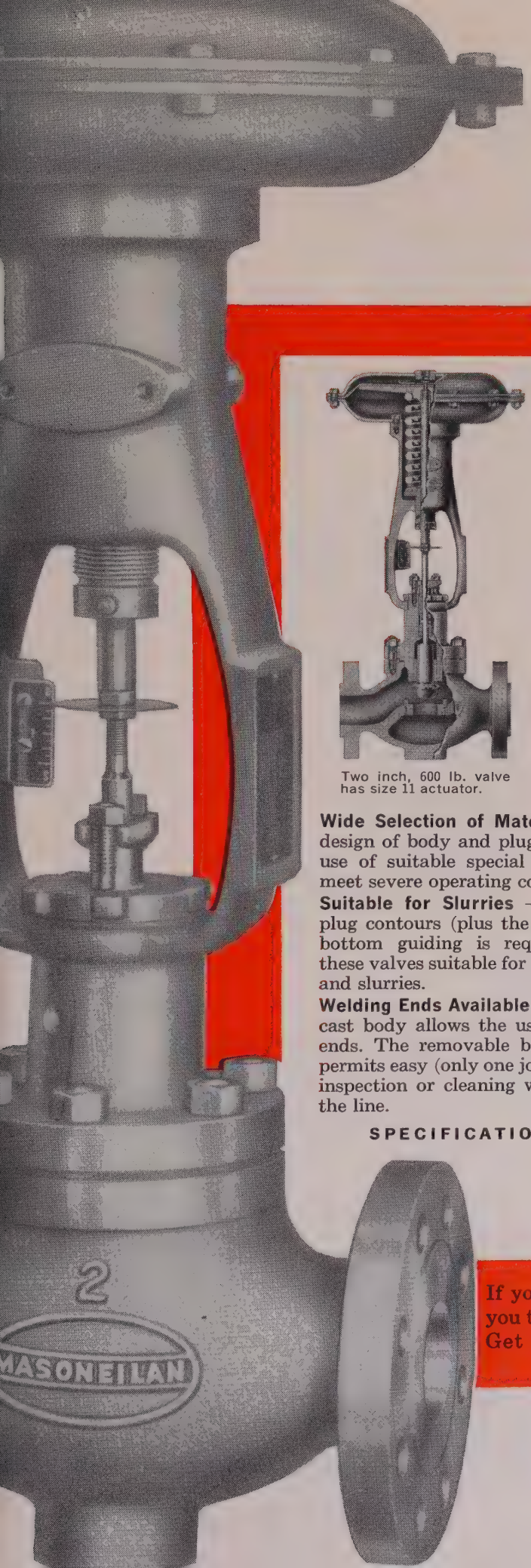
With the introduction of this new line of solid-cast control valves the advantages of single seat design become available for a substantially wider scope of application, from the simple to the most severe. Consider these premium features built in as standard, available to you at no extra cost.

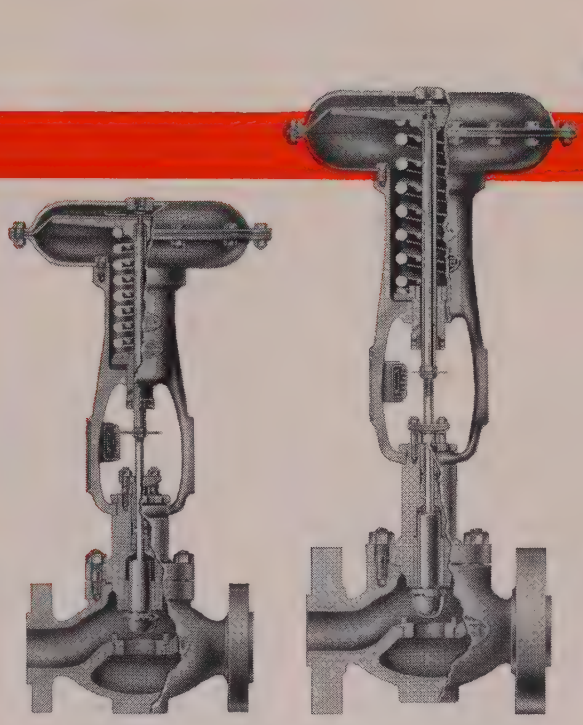
- **High Capacity** — top guiding, unrestricted seat ring area, body and plug contours provide greater capacity than most top-and-bottom-guided double seated valves of comparable sizes.

- **High Pressures and Pressure Drops** — high capacity is attained with minimum seat ring areas, resulting in less unbalance force, permitting higher pressure drops. Heavy guiding throughout full stroke results in a minimum of unsupported plug length and allows high pressure and high pressure drop applications without lateral vibration. Generous guide surfaces and large plug stems are sized in accordance with body rating.

- **Wide Selection of Reduced Capacity Trim** — for those applications where velocity due to high drop is a consideration (or where future requirements for larger capacity are a factor) a wide selection of reduced capacity trim is available — and interchangeable in comparable valve sizes and ratings (see table). The proper relationship between stroke and trim size is maintained in order to provide the strongest possible plug tip, particularly in hard, brittle materials.

Valve Size	Available C_v Ratings										
¾	1.5	3.2	5.4	8							
1	1.5	3.2	5.4	12							
1½	1.5	3.2	5.4	12	25						
2	1.5	3.2	5.4	12	25	46					
3				12	25	46	110				
4					25	46	110	195			
6						46	110	195	400		
8							110	195	400	640	
10								195	400	640	1000





Two inch, 600 lb. valve has size 11 actuator.

Two inch, 1500 lb. valve has size 13 actuator.

Two inch, 2500 lb. valve has size 15 actuator.

Wide Selection of Materials — the design of body and plug permits the use of suitable special materials to meet severe operating conditions.

Suitable for Slurries — body and plug contours (plus the fact that no bottom guiding is required) make these valves suitable for viscous fluids and slurries.

Welding Ends Available — the solid-cast body allows the use of welding ends. The removable bolted bonnet permits easy (only one joint to break) inspection or cleaning with valve in the line.

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CONDENSATIONS OF ANNUAL MEETING PAPERS

General Session I

1. **The Electrical Properties of Select Fractions of Cellulose Pulps,** T. D. Callinan, J. S. Crimi, P. M. Schwartz and L. H. Wirtz, International Business Machines Corp., Yorktown Heights, N. Y.

The electrical properties of Bauer-McNett fractions of unbleached sulfate, semibleached sulfate, and groundwood were found to differ at different relative humidities. The dielectric constants and dielectric loss factors, for example, of the long unbleached sulfate fibers were only half as great as those of short unbleached sulfate fibers. The measurements were made over a frequency range of 0.1–100 kc. and a relative humidity range of 0.92%. Chemical analysis of the pulp fractions revealed significant differences in lignin, cellulose, and ash content in each fraction. This is thought to explain the differences in the electrical properties and the moisture adsorptivities of the fractions also.

2. **Deinking—Present and Future,** A. J. Felton, Shartle Div., Black-Clawson Co., Middletown, Ohio.

This study collects and puts into prospective, technical, and economic data concerning recognized types of deinking systems. Flow diagrams and descriptions of some systems are made public here for the first time.

The history of deinking development is reviewed from 1695 to 1960.

Descriptions of 10 systems in current use are based on a recent survey of the industry. Each system is presented graphically as well as verbally. Stress is placed on the choice of equipment, chemical consumption, bleachability, fiber yield, and water consumption of each.

3. **The Application of a Centrifugal Water-Retention Test to Pulp Evaluation,** E. F. Thode, J. G. Bergomi, Jr., R. E. Unson, and Rene E. Unson, The Institute of Paper Chemistry, Appleton, Wis.

A new centrifugal method (designated the CWR test) for estimating the swollen volume of papermaking pulp has been developed. This method gives excellent reproducibility and precision even with highly beaten pulps and has the potential advantage of permitting analytical interpretation of the process of centrifugal water extraction. Swollen volume values estimated by this method are about 10% lower than figures obtained by the filtration resistance method, presumably because of fiber deformation and "deswelling." Very good correlations with sheet strength properties were obtained when centrifugal water retentions and fiber-length indices were employed in a beating and refining study on sulfite pulp. It is concluded that this centrifuge method offers a fairly convenient method for the *empirical estimate* of the swollen volume of papermaking pulps, but that it cannot be considered as unbiased *measure* of swollen volume and must be viewed cautiously as a criterion of sheet strength.

4. **Production of High Wet-Strength Paper by Wet-End Addition of Dialdehyde Starch,** B. T. Hofreiter, G. F. Hamerstrand, C. L., Mehltretter, W. E. Schulze, and A. J. Ernst, Northern Regional Research Laboratory, Peoria, Ill.

Dialdehyde starch, a product of the periodic acid oxidation of cornstarch has recently been shown to produce wet strength when applied to paper as a tub size. The present work further extends the usefulness of this new wet-strength agent through the defining of conditions for wet-end addition. Excellent wet-strength and improved dry-strength properties result from 0.5 to 10% application based on the dry pulp. The manner of dispersion of the dialdehyde starch, use of alum, and pH were found to be determinate factors in the retention of dialdehyde starch by the cellulosic fibers. Advantages of the wet-end addition of dialdehyde starch in papermaking are: rapid development of wet strength without heat, no extended cure required for either the stable dialdehyde dispersions or the newly formed sheets, ease of broke recovery, and commericial availability of dialdehyde starch.

The economic importance of deinked fiber is analyzed statistically, and its role in conserving primary fiber sources is noted.

Future development of more effective deinking systems is treated in a discussion that embodies the opinions of at least 10 experts in the field.

Alkaline Pulping Session

1. **Comparison Study of Full Chemical Pulping—Alkaline Processes,** J. R. Peckham and V. Van Drunen, The Institute of Paper Chemistry, Appleton, Wis.

2. **Cooking of Sawdust by the Sulfate Process,** K. H. Lauer, University of Alabama, University, Ala.

3. **Commercial Pulping by Total Chemical Using Elemental Sulfur in the Digester,** B. Cox, H. M. Owen and R. R. Fuller, Gulf States Paper Co., Tuscaloosa, Ala.

4. **Effect of Sulfite to Carbonate Ratio on Neutral Sulfite Semichemical Pulping,** C. B. Christiansen, Diamond Alkali Co., Painesville, Ohio.

The reputation of sodium carbonate as an "inactive" chemical in the kraft pulping reaction has no doubt contributed to its being considered to have a similar role in neutral sulfite pulping. In the latter process it is usually referred to as a buffer or neutralizer of wood acids. Since a wide variety of sulfite/carbonate ratios is in commercial use, the effect of carbonate in the pulping reaction needs clarification.

A laboratory study of small scale cooks was made to determine the effect of sulfite/carbonate ratios on pulp yields. One sequence of time-series digestions maintained a constant charge of sodium oxide with different sulfite/carbonate ratios. A second sequence of time-series digestions maintained a constant charge of sodium sulfite and varied the sulfite/carbonate ratios by additions of sodium carbonate.

Four cooks were then made in a 2-cu. ft. digester to obtain sufficient pulp for evaluation at each of the four sulfite/carbonate ratios: 4, 3, 2, and 1. The required cooking times to reach similar yield levels were predicted from the miniature-scale digestions. Reductions in cooking times, by additions of sodium carbonate to a constant sulfite charge, were confirmed. Physical tests on the four pulps showed similar strength characteristics. Unbleached pulp brightnesses decreased as carbonate content increased. Higher bleach demand was indicated for pulps from a sulfite/carbonate ratio of 1.

Chemical Products Session

1. **Uses of Sulfate Turpentine,** C. E. Tyler, Hercules Power Co., Brunswick, Ga.

2. **Studies on the Chemistry of Aspenwood V. An Investigation of Various Aspen Spent Liquors as Sources of Para-Hydroxybenzoic Acid and Other Compounds,** Irwin A. Pearl and Donald L. Beyer, The Institute of Paper Chemistry, Appleton, Wis.

The suitability of the spent liquors from the pulping of aspenwood by the acid sulfite, neutral sulfite, kraft, and soda processes as sources of *p*-hydroxybenzoic acid and other aromatic compounds was studied and compared with aspenwood. Acid sulfite, kraft, and soda spent liquors proved to be satisfactory raw materials for *p*-hydroxybenzoic acid recovery, but neutral sulfite semichemical spent liquor wielded only a small percentage of the *p*-hydroxybenzoic acid originally present in the wood. Aspenwood and aspen spent pulping liquors were submitted to both acid and alkaline hydrolysis, and the vanillin, syringaldehyde, *p*-hydroxybenzaldehyde, vanillic acid, syringic acid, *p*-hydroxybenzoic acid, and *p*-coumaric acid produced were determined by means of paper chromatography and ultraviolet spectrophotometry. Material balances were made. In addition, paper chromatography indicated several unknown compounds to be present in these reaction mixtures. Quantitative data on known compounds indicate that unbleached pulps may have considerable *p*-hydroxybenzoic acid and other compound-yielding materials present.

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3. **Production of Lignin and Organic Acids from Kraft Pulping Black Liquor,** M. E. Findley, Auburn University, Auburn Ala.

The purpose of this investigation was to study possible methods of producing organic products from kraft pulping black liquor, and to obtain some idea of the economic feasibility of such a process. Since thiolignin has limited value as is, it was felt that a low cost would be necessary to establish an appreciable market.

The data indicate it is possible to use a portion of the black liquor to produce acetic and formic acids and thiolignin with cooking chemical recovery. The processing would include oxidation of the liquor, acidification, filtration, drying, extraction, or distillation, possibly furfural production, and conventional cooking chemical recovery, possibly with modification. A comparison of the potential value of the black liquor components under various processing conditions is made. This comparison indicates that a portion of the liquor might provide an increase in value of $0.10 per 100 lb. of the black liquor studied, based on a thiolignin price of $0.02 per lb. On this basis it is felt that a suitable market might be developed, and an economic process realized.

Fourdrinier Session

1. **Rope Carrier Practices,** H. H. Mullins, Olin Mathieson Chemical Corp., West Monroe, La.

Rope carrier practices vary widely throughout the industry and it was felt it would be beneficial to make a study of these practices.

There are several types of rope carrier systems, one being the single rope system which uses one continuous rope doubled back upon itself.

In mills having three- and four-deck stack drying systems on heavy board machines, a three-rope system is often used. However, the majority of rope cariers are a two-rope system.

There are several types of transfers for passing the sheet from one section to the next. Some mills use automatic transfers; others use a more flexible transfer system which permits the tail to be pulled out if necessary and then fed back into the next section at the appropriate time.

Ropes used in rope carrier systems were originally made of cotton, but spun nylon is now widely used. Spun nylon rope has the advantage of long life without the undesirable high breaking strength of filament nylon.

Rope life is primarily dependent upon proper tension, well designed correctly aligned sheaves, and proper splices.

2. **A Practical Approach to Open Side Calender Design,** Joseph E. Perkins, The Black-Clawson Co., Paper Machine Div., Watertown, N. Y.

A discussion of the method used by engineering to improve the design of open side calenders.

Before actual design work was started a complete review was made of all the requirements needed to produce a good calender. This review involved a complete investigation of the following four items.

1. Proper sizing of the equipment for the job.
2. Arranging components for ease in operating.
3. Designing for easy service.
4. Providing for the addition of accessories.

The results obtained by this approach are illustrated by describing some of the important design features of the calender in terms of the four basic items noted above.

3. **The Hydromechanics of Pulp Slurries,** L. Ingmanson, The Institute of Paper Chemistry, Appleton, Wis.

The fiber-water system is viewed from its hydromechanic, rheological, and colloidal aspects. The complexity of papermaking suspensions used for commercial sheet-forming conditions is emphasized. Three types of fiber-water systems are defined as (1) free fiber suspension, (2) loose fiber network, and (3) compacted fiber mat. Studies by various workers of flocculation, forced flow of fiber suspensions, and drainage of compacted mats are briefly reviewed for these systems. Application of some of the studies to design, operation, and control of fourdrinier paper machines is discussed.

4. **Process Control as Related to Fourdrinier Operations,** R. L. Traxler, Scott Paper Co., Chester, Pa.

Process control as generally practiced by the technical control departments in the paper mills of Scott Paper Co. is discussed. Particular emphasis is placed on furnish, chemical addition, and white water control. Examples of useful laboratory test results are cited. Quick and meaningful tests which can be used as control guides must be adapted to each machine and each process.

When the collected process information is correlated with operating experience, process control can then be a positive force in assisting production to attain the quality objectives.

Acid Pulping Session I

1. **Magnesia-Base Pulping and Recovery,** W. J. Darmstadt, Babcock & Wilcox Corp., Barberton, Ohio, and G. H. Tomlinson II, Howard Smith Paper Mills, Cornwall, Ont., Canada.

The magnesium acid sulfite process and the more recently developed magnetfite process are suitable for the production of a wide range of dissolving and papermaking pulps. Such processing can be used to advantage in many existing sulfite mills to extend the range of wood, to up-grade the products, etc. Complete modernization of the mill would involve chemical recovery. Recent studies allow simplification of processing in the liquor make-up stage thus enhancing the basically simple recovery operation. For new mills the capital cost and pulp production costs for magnefite appear attractive in relation to kraft.

2. **Chemical Recovery from Sulfite Spent Liquors by the Atomized Suspension Technique,** W. H. Gauvin, Pulp and Paper Research Institute of Canada, Montreal, Que., Can.

A brief summary of the general principles of the atomized suspension technique (AST) and description of its applications to the recovery of chemicals from pulping liquors are given. A review of the practical experience gained during the past year in the continuous operation of larger scale equipment than heretofore reported is also presented.

Pyrolysis of the sulfite liquor under reducing conditions—as practiced in an AST reactor—yields a solid product consisting essentially of sodium carbonate, with small amounts of sodium sulfate (less than originally present in the liquor) and no other sulfur compounds, such as sodium sulfide or thiosulfate. Combustible gases of good calorific value are also produced from which the sulfur can be recovered also completely as SO_2, while all the water present in the liquor is converted to steam at the pressure level desired for re-use.

Engineering considerations such as materials of construction, thermal self-sufficiency, heat transfer rates, and reactor throughput are discussed.

3. **Sivola Sodium-Base Pulping and Chemical Recovery Process,** E. H. Kennedy, Combustion Engineering, Inc., New York, N. Y.

This paper presents a short review of the Sivola sulfite recovery process presented a year ago and will bring the industry up to date on what has developed since then. This matter will include a summary of two stage plant digester cooks made since then on western hemlock and red fir and on Wisconsin poplar. Also will be reviewed the results of laboratory digester cooks being made at the Forest Products Research Laboratory on oak and pine by three different types of pulping and of laboratory digester cooks made by a paper mill research laboratory on oak, pine, birch and poplar by the sodium bisulfite-liquid sulfur dioxide pulping process.

Cylinder Board Session I

1. **Application of Wires in the Paperboard Industry,** N. O. Weil, W. S. Tyler Co., Cleveland, Ohio.

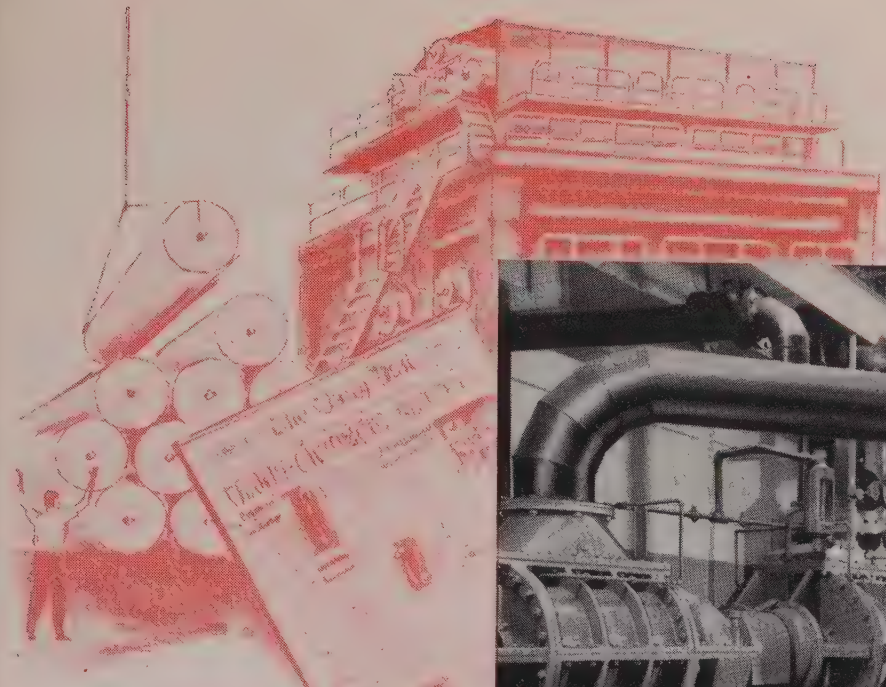
2. **The Practical Aspects of Microorganism Control in Cylinder Board Mills,** J. J. Dietzel, Buckman Laboratories, Inc., Memphis, Tenn.

This paper deals with the important factors influencing growth of slime-and odor-forming microorganisms in cylinder board machine systems. The role of proteinaceous, carbohydrate, and chemical substances is reviewed and related to the growth of microorganisms and the development of odor. Certain losses and problems not always associated with the growth of bacteria and fungi are discussed. This paper stresses emphasis on methodical and thorough clean-up as a necessary complement to the effective use of toxicants. Procedures are given for clean-up, sanitation, and control of microorganisms.

3. **Chemical Cleaning Procedures in Paperboard Industry,** R. Kipp, Oakite Products, Inc., New York, N. Y.

4. **Whys and Hows of Cleaning in Board Mills,** D. F. Lehman, The Black-Clawson Co., Shartle Div., Middletown, Ohio.

This paper highlights the tremendous economics which can be realized through the proper application of basic principles and suitable equipment in the waste paper and liner systems.



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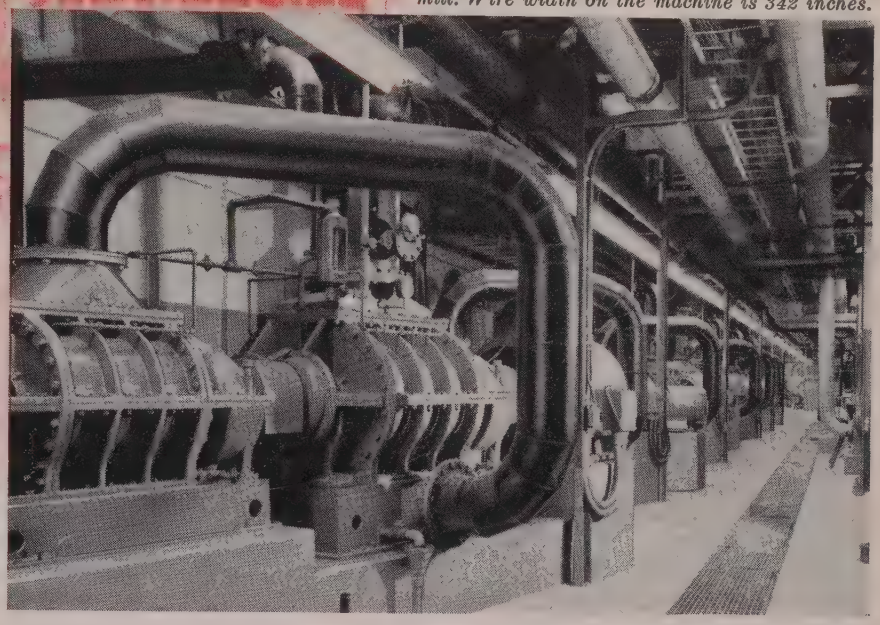

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Today's competitive markets force board mills to improve quality and production, yet reduce costs. Thus, the paper explains how reduced costs can be realized through purchasing a lower cost furnish which is up-graded. Several other cost reductions are enjoyed by similar techniques.

It is pointed out that wide variations in the types of furnishes used and end products to be made in board mills necessitate consideration of certain specific types of equipment and processing methods in the cleaning system. Only full knowledge and application of the basic principles of pulping, defibering, centrifugal cleaning, and screening, will enable the mill to realize maximum economies.

Adhesive Testing Session

1. **A Measure of Surface Tension and Surface Film Elongation,** P. B. Davidson, Mellon Institute, Pittsburgh, Pa.

2. **The Correlation of Laboratory Tack Testing with the Machine Performance of Adhesives,** F. Rosenblum and W. Neuss, Armour Alliance Industries Alliance, Ohio.

By means of a laboratory model T-A-C tester, a series of carton-sealing adhesives have been evaluated for strength of tack in the laboratory. Both resin and vegetable adhesives of varying solids contents and viscosities have been studied. These adhesives have then been run commercially on a Clayborne carton sealing machine, and some correlation has been observed between laboratory evaluation and machine performance.

3. **The Theory of Adhesion,** J. J. Bikerman, Massachusetts Institute of Technology, Cambridge, Mass.

Agricultural Fibers Session

1. **A Search for New Fiber Crops,** H. J. Nieschlag, G. H. Nelson, and I. A. Wolff, Northern Regional Research Laboratory, Peoria, Ill., and R. E. Perdue, Jr., Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md.

Among lesser known members of the plant kingdom are undoubtedly a number that could be developed into economic crops. Uses might in favorable instances offer minimum competition to crops now in surplus. To find and exploit such plant species a research program having this objective is under way in the Agricultural Research Service of the United States Department of Agriculture. This report concerns that part of the program directed toward a search for plants that may have potential as sources of pulp for paper.

To facilitate a search for new fiber-producing plants a scheme to evaluate them as possible sources of papermaking pulp was devised. Included in the evaluation of the plants are their botanical characteristics, chemical composition, dimensional measurements of fibrous constituents, yield after sodium chlorite maceration, and a qualitative physical and visual appraisal. Samples are assigned numerical ratings based on an assessment of merit in each of these categories. By summing these numerical ratings, a total point evaluation is obtained that is indicative of the potential of a particular species as a pulp crop.

This method of evaluating plant materials was applied to 58 plant species representing 11 botanical families. Representatives of the grass, legume, and mallow families appear to be the most promising from the relatively small number of samples examined.

2. **Water Sorption of the Main Cell Wall Constituents,** M. W. Luthgens, Nalco Chemical Corp., Chicago, Ill.

The sorption properties of cellulose were known before the other important constituents, hemicellulose and lignin, were considered. These were systematically investigated using a dynamic method to determine the adsorption and desorption curves from which the changes of the free energy at saturation were calculated.

It was found that hemicelluloses develop a much higher, and lignin a lower, rate of sorption than previously assumed. The sorption of the cell wall constituents depends on the microstructure as well as the chemical constitution.

The amorphous hemicelluloses are able to bind more water molecules by hydrogen bonds than partially crystalline cellulose, because of the greater number of free hydroxyl and carboxyl groups present. This is also important for our present conception of interfiber bonding, in which the same groups and chemical bonds participate. The rate of sorption of hemicelluloses with hexosan structure was found to be somewhat higher than that of pentosans.

The sorption of isolated lignin depends largely on the physical and chemical changes during preparation. Extracted lignins (Brauns, dioxane, methanol) show a much lower rate of sorption than residual lignins (Klason, Freudenberg). Lignin *in situ* is assumed to possess a rate of sorption between these two extremes.

3. **Morphological Properties of Cotton and Wood Fibers. Part I: Cotton Linters,** K. A. Jurbergs, Buckeye Cellulose Corp., Memphis, Tenn.

Electron microscopic evidence is presented that the cellulose bundles form ridges on the surface of cotton linters and that the surface structure of these fibers is very similar to staple cotton. The structural surface changes have been followed after different purification processes, such as extractions of the raw linters and commercial pulping processes. Commercial pulping removes the primary wall. The fibers are mainly covered by the outside layer of the secondary wall. The fibrillar bundles in this layer have a wide helix angle (50–60°). The subsequent layers of the secondary wall have perfectly parallel aligned bundles of fibrils with a narrow helix angle (24–30°).

Blending hydroxyethylated cotton linters with untreated fibers helps to overcome the inherent beating difficulties of the cotton linters. The added material reinforces not only the existing bonds but also forms new bonds among fibers and bundles of fibrils generated in the beating process. Electron microscopic evidence is presented about the structural differences between blue and yellow staining fibers with the Simons stain and also about structural changes on the surface of fibers treated with an enzyme solution.

Water Session I

1. **Design of Paper Machine Wet Ends for Maximum Internal Water Use in a Paper Mill,** H. L. Berg, Sveen-Pedersen Div., E. D. Jones Corp., Long Island City, N. Y.

2. **Operating Functions for Efficient West End Design of a Paper Machine,** O. F. Hutchinson, Peter Cooper Corp., Gowanda, N. Y.

Corrugated Containers Session I

1. **Supervisory Practices in Container Plants,** R. W. Buttery, Bathurst Containers Ltd., Montreal, Que., Canada.

This paper is based on information gathered by a subcommittee consisting of A. C. Reid of Pembroke Shook Mills, Douglas Adams of Canton Corrugated, and the author.

The survey covered 19 plants in the U.S.A. and Canada. The summary was analyzed to give highs, lows, and average figures on such things as:

Number of supervisors used in relation to square feet produced, manufacturing area, number of order items per month, etc.
Average pay for the various classifications of supervisors, practices regarding incentive pay and overtime.
Cost of supervisors per dollar of sales.
Usual practices in using supervisors on second and third shifts.
Training of plant supervisors.
Meetings attended by supervisors, their purpose and duration.

2. **Unitizing of Corrugated Containers,** J. A. Comly, Connelly Containers, Inc., Philadelphia, Pa.

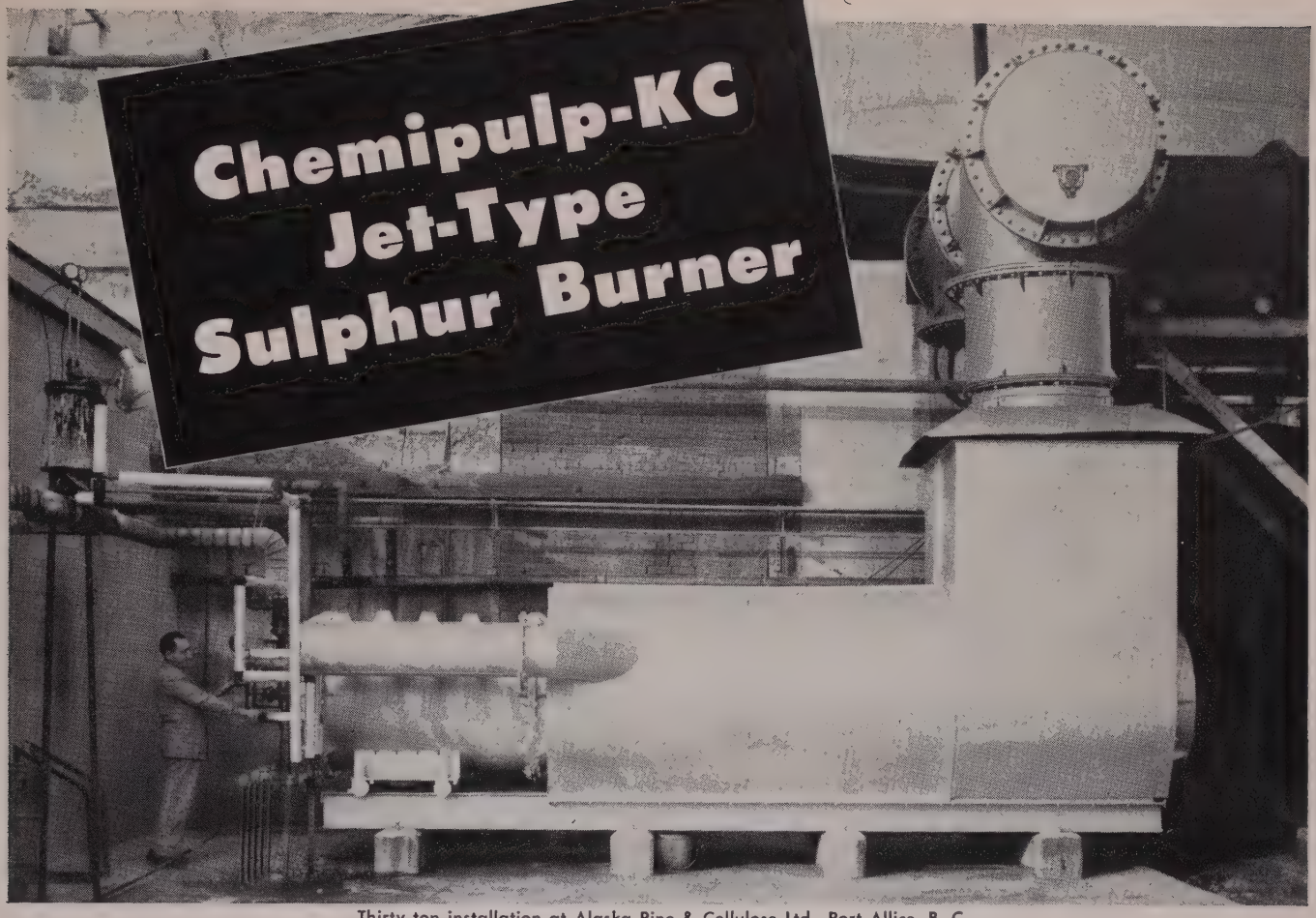
The large increase in the unitizing of corrugated containers is bringing about a vast change in plant layouts, methods, bundling, storage, and shipping concepts.

Unitizing has increased expenditures for equipment and materials to accomplish its purpose. It has decreased by 15 to 25% the volume per outgoing shipment. However, with proper understanding and training on the part of all company personnel, unitizing will pay for itself, but only if the desire and initiative are there. It will do this by providing better services to customer; helping to increase production (both real and potential); and helping to lower costs by speeding up the finishing lines and doubling or tripling floor space use; decreasing loading and unloading time and thereby increasing the number of trips per driver per day.

Unitizing is good for us. We should encourage it, not with tongue in cheek, but with interest and foresight.

3. **Operating Experiences with Tapered Mechanical Glue Roll Drives,** R. A. Sherman, Corrugating Technicians, Inc., Tenafly, N. J.

This intensely practical paper is based upon experience with tapered mechanical glue roll drives in the improvement of bonding corrugated board. The causes of poor bonding are discussed, and the use of tapered mechanical drives in the elimination of these shortcomings is presented. The effects of tapered drives on improving pin adhesion and top-to-bottom compression are discussed and illustrated with slides. Optimum ratios for the various speeds are presented. The marked reduction in adhesive costs and the advantages accruing from better board production are demonstrated by the empirical data which is presented.



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4. **Scheduling a Container Plant,** R. P. Caponi, Union Bag-Camp Paper Corp., Chicago, Ill.

Acid Pulping Session II

1. **Sodium-Base Recovery—Western Precipitation Process,** R. Q. Boyer, Western Precipitation Corp., Los Angeles, Calif.

The WP recovery system utilizing the crystallization separation of the sodium carbonate from the sodium sulfide of the smelt, reacts all of the separated sodium sulfide with the spent liquor sulfite sulfur through an oxidation reduction reaction known as the Bradley process. The reacted liquor is evaporated and burned in inexpensive kraft equipment. Considerable of the sulfur appearing as sulfur dioxide in the furnace gases holds the cyclic system in sulfur balance. The cooking liquor is produced by absorption recovery of the flue gas sulfur dioxide in a sulfite-bisulfite solution that uses the recovered sodium carbonate as the make up base. This system at the Consolidated Water Power and Paper Co. experimental recovery plant has completely processed spent liquor from sodium-base acid sulfite, two-stage sulfite and NSSC cooks, separately and in combinations. The scale formation in the evaporators is eliminated with the proper pH control by the amount of recycled sulfide sulfur. This sulfur can be either increased with sodium sulfate addition or reduced with inventory sodium sulfide addition, respectively, to the firing liquor. A pressure-boiling point rise relationship is used to control the evaporation-crystallization. High sulfur, soda, and heat recoveries are possible.

2. **Sodium-Base Recovery—The Mead Process,** W. J. Darmstadt, Babcock and Wilcox Corp., Barberton, Ohio.

3. **Sodium-Base Recovery—Stora Kopperberg Process,** K. N. Cedarquist, K. Ahlborg, and B. O. Lunden, Stora Kopperbergs, Bergslags AB, Falun, Sweden. and T. O. Wentworth, Chemical Process, Inc., Cleveland, Ohio.

Cylinder Board Session II

1. **Rubber-Covered Rolls for Cylinder Paper Machines,** John J. Connors, Raybestos-Manhattan, Inc., Passaic, N. J.

The author's paper covers four subjects under the subtitles of rubber, the nip, press rolls, and care and maintenance.

Under *rubber* the use of synthetic rubbers is discussed.

The *nip* refers to a progress report on research concerning the relationship between roll diameters, rubber thicknesses, and hardnesses.

The *press roll* subtitle covers some general thoughts on good roll performance and the proper selection in determining hardnesses.

Care and mantenance is designed to pass on some helpful hints covering the use and maintenance of rubber coverings.

Microbiological Session

1. **The Correlation and Precision of Five Day and Manometric Biochemical Oxygen Demand in the Range of One to Twenty Parts Per Million,** E. Dillingham, The Institute of Paper Chemistry, Appleton, Wis.

2. **A Research Tool Adapted for Use in the Industrial Laboratory,** L. L. Wolfson, P. Song, and J. R. Nelson, Nalco Chemical Corp., Chicago, Ill.

One of the most important instruments in the basic research biology laboratory is the Warburg respirometer. This instrument, which measures the respiration of living cells, is used to determine the metabolic activities of bacteria. The Warburg apparatus has also proved to be a very useful tool in the industrial research laboratory. A test method has been devised for determining the bacteriostatic activity of various chemicals against certain bacteria. Test results are obtainable in one day's time against a specific organism or a group of organisms found to be associated in slime formation. The results obtained with the Warburg respirometer in the laboratory are illustrated with charts and graphs.

3. **A New Candidate Slimicide,** M. Legator, Shell Development Co., Modesto, Calif., and A. Stern, West Virginia Pulp and Paper Co., Covington, Va.

Acrolein, the simplest of the α, β unsaturated aldehydes, is a highly reactive compound. *In vitro* date indicate it is effective in controlling gram-positive, gram-negative, and acid fast bacteria, as well as fungi and algae, at low concentrations. This compound reacts with sulfhydryl groups and this is possibly one of its modes of action. Time of kill studies indicate a rapid lethal action. This action is influenced by temperature and pH of the substrate.

White water tests, including the slime-stick method, indicate complete sterilization of slime populations at low concentrations. Excellent results were obtained in machine tests using concentrations of 2 to 4 p.p.m. of the chemical. No resistant organisms to the chemical in these machine tests have been encountered to date.

Since acrolein possesses lachrymatory characteristics, its application requires special but relatively simple metering devices.

4. **The Slime Board Method of Paper Mill Toxicant Evaluation,** C. R. Leckey, Oxford Paper Co., Rumford, Me.

A device which can be used in the laboratory and on paper machines for evaluations of toxicants is described. The laboratory model is a system in which an artificial white water is circulated over the slime boards. The artificial media described is specific for the study of a particular type machine furnish but modifications are mentioned. The machine model is attached directly to the machine and uses machine white water. The measure of microbiological toxicity is determined by making plate counts of the accretion. Both laboratory and machine data are given for three toxicants. There appears to be a good correlation between the two sets of data. However, further work is indicated because of insufficient data.

Water Session II

1. **Water Treatment for Paper Mill Power Plants,** H. E. Bacon and L. G. Von Lossberg, Sheppard T. Powell & Associates, Baltimore, Md.

2. **Clarification of High Color Waters,** C. T. Wise, J. E. Sirrine Co., Greenville, S. C.

3. **Water Treatment at Abitibi Mills,** G. Stuart, Abitibi Power & Paper Co., Ltd., Toronto, Canada.

4. **Water Conservation by Re-Use,** L. Klinger, Whippany Paper Board Co., Whippany, N. J.

Structural Fibrous Materials Session

1. **Factors Affecting the Warping of Fiberboard Roof Insulation,** J. W. Geddes and J. J. Perot, National Gypsum Co., Buffalo, N. Y.

Fiberboard is used extensively as insulation applied over steel, poured gypsum, and other types of concrete roof decks. If the material warps or buckles, severe problems are created for the applicator of the built-up roofing used in this type of construction.

Warping is directly related to the moisture content of the fiberboard insulation, its color, and, to the time of exposure. Warping decreases (at the same moisture content) as thickness increases.

Warping is caused by a moisture gradient between the upper and lower surfaces of the insulation. Migration of moisture from the warmer upper face to the cooler lower face plus loss of moisture to the air from the upper surface causes expansion of the lower surface, contraction of the upper surface, and results in warping.

No significant differences in warping tendencies were noted among a series of commercially available products; indicating that type of fiber, pulping processes, and machine formation are not major factors in this problem.

In commercial practice, difficulties can be eliminated by:

1. Manufacturing the material with low moisture content.
2. Observing proper shipping and storing procedures.
3. Following recommended application procedures including prompt application of the built-up roof.

2. **Dielectric Heating for Drying Wood Fiberboard,** D. C. Carter, Johns-Manville Corp., Manville, N. J.

Wood fiberboard can be dried faster in an existing conventional hot-air oven if dielectric heating is used. By installing the high-voltage plates inside the exit end of the existing drier, no additional floor space would be required.

One-half inch board was dried by combined hot-air and dielectric heating to about 7% moisture content. By using dielectric heating for a 4-minute period, total drying time was reduced 15 to 20%. Dielectric-heated board had more even moisture distribution throughout its thickness, and a more constant final moisture content was achieved. The conventional humidification process after drying could possibly be eliminated.

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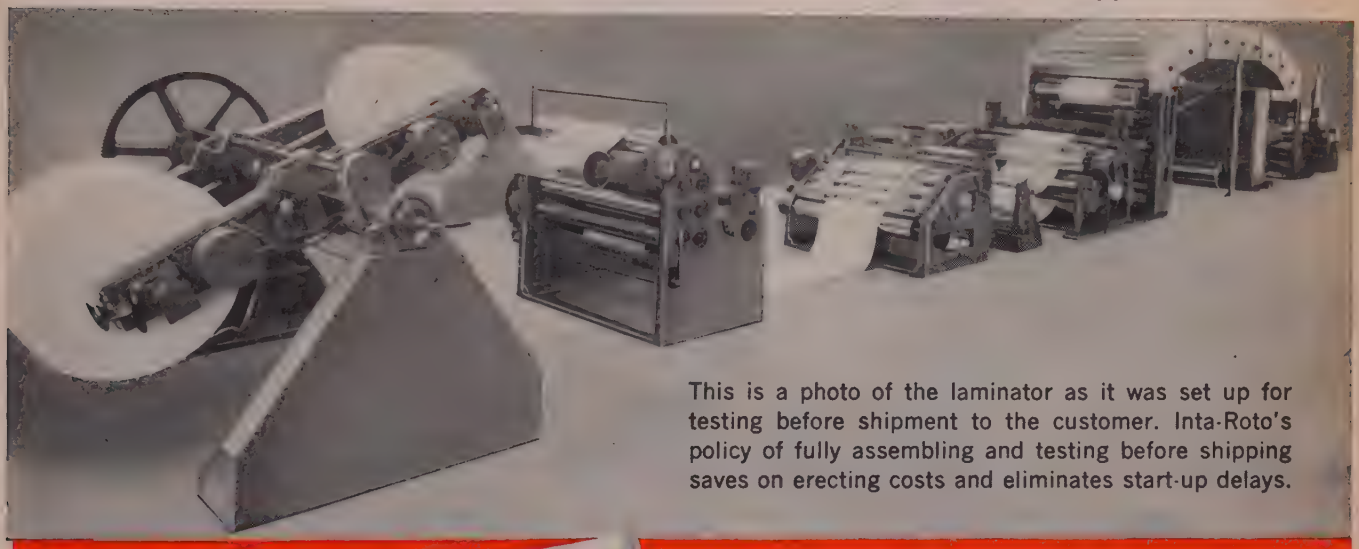
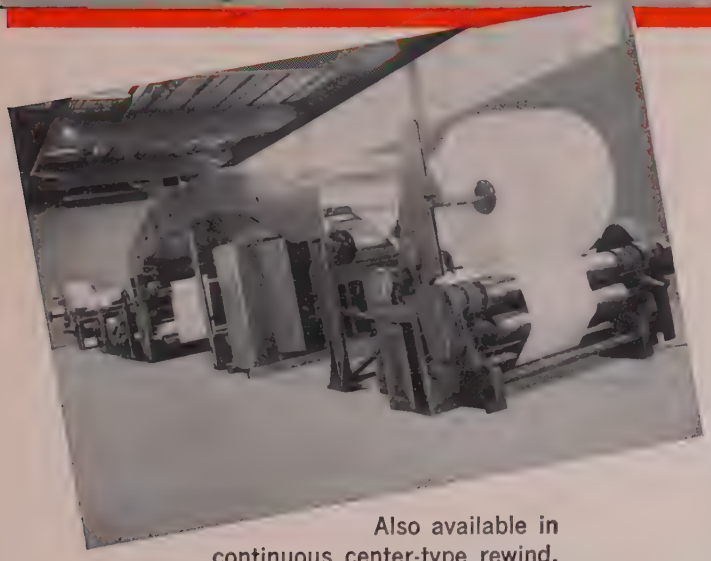


This is a photo of the laminator as it was set up for testing before shipment to the customer. Inta-Roto's policy of fully assembling and testing before shipping saves on erecting costs and eliminates start-up delays.



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It is more costly to heat dielectrically than by hot air. However, it may be justified if an existing plant needs increased drying capacity and if no additional floor space is available for lengthening the existing hot-air drier.

3. **Unexpected Variables Affecting the TAPPI-SFMC Drainage Time Tester of Suggested Method T 1002 sm-51,** W. G. Coggan, Johns-Manville Corp., Manville, N. J.

Difficulties experienced in predicting the drainage characteristics of groundwood and semichemical pulps on insulating board forming machine have prompted an investigation of some variables not included in the Standard Drainage Time Test for Insulating Board Pulps (T 1002 sm-51). The variables investigated were size and alum addition and cleanliness of the pulp and water. The pulp types tested were willow and pine groundwoods, neutral sulfite and cold soda semichemicals, and Asplund-defibrated pine. The drainage times of willow groundwood and cold soda pulps, which were poorly washed, were significantly increased after alum addition. Apparently, the alum reacted with the dissolved solids carried through the process to form a gelatinous precipitate which increased the drainage time by partially blinding off the screen. Pine groundwood, neutral sulfite semichemical pulp, and Asplund-defibrated pine did not exhibit this effect. Size and alum addition had no measurable effect on the drainage time of any of the pulps, when dewatered pulp and tap water were used in the test. These data indicate that the Suggested Method of Determining the Standard Drainage Time of Pulp for Insulating Board be expanded to include as many conditions as possible to which the pulp will be exposed in its environment on the forming machine, since its "Machine Drainage Time" may be significantly different than indicated by the standard test, which uses dewatered pulp and fresh tap water for dilution.

4. **The Relation of Fiber and Pulp Properties to the Properties of Structural Fiberboard Products,** E. D. Jones, The Institute of Paper Chemistry, Appleton, Wis.

In recent years a number of laboratories throughout the world have been engaged in determining the relationship between basic properties of cellulose fibers and pulp suspensions and the characteristics of paper made from such fiber. The objective has been to expand our understanding and control of these relationships beyond that obtainable through laboratory small-scale simulation of commercial production. When we extend this type of analysis to insulation board and hardboard, we must deal with the much greater chemical and physical complexities of the fibrous raw materials. A review is presented of the recently published work on pulp evaluation, including that on fiber strength, fiber flexibility, drainage resistance, surface area, swollen volume, and bonding strength. The extent to which these tools may be applicable to structural fibrous materials is considered and possible modifications of present techniques for such purpose are suggested.

5. **Asphalt and Its Use in Insulation Board,** E. M. Lorenzini, American Bitumuls & Asphalt Co., San Francisco, Calif.

A brief introductory review of the source and manufacture of petroleum asphalts with some emphasis on the basic characteristics, and their identification and modification.

Comment on the pertinent properties of asphalt and the use in board for (1) hot surface application, (2) cold pulverized integral admixture, and general effects on board density, sizing, and strength.

Brief review of the operational development of emulsified asphalt in the board industry, covering effects of coarse and fine dispersions, reflected by clay and chemical type emulsions. Discussion of the pertinent asphalt emulsion qualities effecting board formation, with particular stress on sizing and strength.

Conjunctive use of pulverized and emulsified asphalt.

Simple use of emulsified asphalt surface coatings at both the wet and dry ends of the board machine.

Corrugated Containers Session II

1. **Product Development and the Production Merry-Go-Round,** H. J. Schlotter, Hoerner Boxes, Inc., Keokuk, Iowa.

This paper deals with the underlying conflict of product development and the production process. It points out the basic concept of development of new products through design with present materials and the development of new products or uses by raw material changes, machinery developments, and special treatments.

Examples of recent development projects are given along with the various methods of how new products can be introduced to production. These methods being a major factor in showing how mature the concept of product development is within a company.

Further suggestions are given on how the end results for greater corrugated usage can best be realized through cooperation, communications, and basic human understanding of working with people.

2. **New Methods for Production Control of Colloidal Silica Antislip Applications on Corrugators,** B. Mendlin, Cornell Paperboard Products, Milwaukee, Wis., and H. J. Wilhoyte, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

A new direct reading indicator method is described for determining the amount and distribution of colloidal silica deposits on paperboard. Correlations are shown relating the amounts of silica found by the indicator and the coefficients of friction for deposits obtained both from fine and from coarse sprays. Six months, production control experience on a corrugator has resulted in machine changes to improve uniformity across the web and from hour to hour. Supplementary information presents correlation work with two laboratory friction testers and a study of the effect of linerboard moisture content on the coefficient of friction.

3. **Production, Progress, and the Manufacturer's Joint,** Jerome J. Kipnees, Atlantic Gummed Paper Corp., Brooklyn, N. Y.

Packaging in the United States has undergone a remarkable transition in the past two decades. Future historians will refer to the age we live in as the era of packaging revolution. The prominence of packaging today can be attributed to a variety of factors including modern industry's acceptance of packaging as an important marketing, merchandising, and selling tool.

Packaging progress in materials, methods, and equipment is surveyed, particularly the contributions of the fiberboard industry.

Advances in manufacturer's joint construction are reviewed along with production and performance problems encountered. The difficulties connected with the extension of corrugated fiberboard packaging into many new fields have directly influenced manufacturer's joint construction and performance.

Manufacturer's joint developments of the future are discussed.

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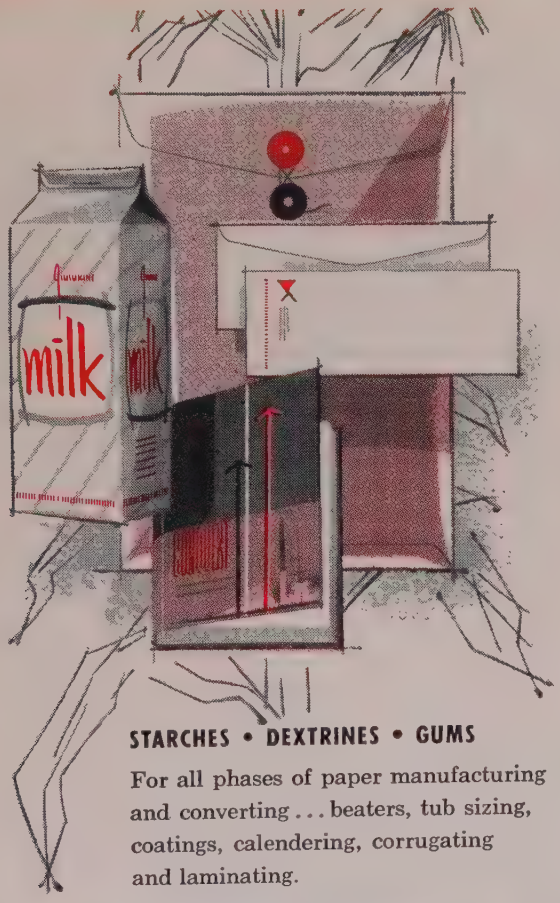

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4. **Sources of Errors and Practices Contributing to Their Reduction,** W. J. Hurrell, Hinde & Dauch, Toronto, Ont., Canada.

Any loss of dollars or customer good will constitutes an error in the corrugated industry. With increased service demands and the more recent complexities introduced to the corrugated industry, the incidence of errors has increased proportionately more than new order growth. This is the causative factor leading to development of the formalized complaint investigation described in this paper, resulting in the listed broad points of discussion:

1. Factory error report.
2. Causes of factory errors.
3. Procedural errors.
4. Communications.
5. Corrective action.

Statistics are given together with sample problems delineating actual procedure within the system discussed.

Conclusions applicable to the author's company system are submitted in summary, so that they may be applied to the problems existing at other plants.

Graphic Arts Session I

1. **Photomicrography of Paper Surfaces and Their Printing Characteristics,** I. M. Bernstein, Flexo-Gravure Inks, Inc., Newark, N. J.

This study is divided into five parts:

1. A description of the optical system used.
2. A description of the quadrant differential illuminator.
3. An account of the author's physico-chemical shadowing technique.
4. Application of the shadowing technique to the surface photomicrography of various uncoated and coated printing papers.
5. Simultaneous shadowed photomicrography of unprinted and printed areas for qualitative evaluation of printing characteristics.

The optical system comprises the use of apochromatic objectives and a Homal (Zeiss) projecting eyepiece for sharpest definition and flatness of field. The camera used is an adaptation of an enlarger using an adapter back equipped with ground glass for focusing under supplementary magnification.

The quadrant differential illuminator for reflective illumination is based on a principle similar to that used in the cardioid dark field illuminator in transmission microscopy, permitting illumination of the area without entry of the beam into the microscope tube.

The shadowing technique consists of applying a layer of a low molar adhesion pigmented material to the surface of the paper and then polishing off the excess. This gives gradations of tone depending on the relative hydrophilicity of the shadowing materials to the surface being shadowed, permitting detailed resolution of structural characteristics.

Photomicrographical slides are shown of shadowed newsprint, S. & S. C., machine coated, off-machine coated (Frailing edge), conventional conversion coated, and cast coated stocks.

The technique developed of shadowing unprinted areas contiguous to printed areas is illustrated by photomicrographical slides in black and white and Ektachrome, allowing interpretation of half-tone and line printing by the various processes.

2. **Factors Affecting Print Gloss and Uniformity,** J. M. Fetsko and A. C. Zettlemoyer, Lehigh University, Bethlehem, Pa.

A review of printability research results reveals that print gloss and uniformity both definitely depend on the interrelation of ink, stock, and printing conditions, and that major attention should be directed to the elucidation of the respective mechanisms. Progress has been impeded partly by lack of suitable instrumentation for evlauating these print quality properties numerically. No routine control tester for characterizing uniformity is currently available, and although many gloss meters exist, it has not been established which angular conditions are best for prints made with various types of ink-stock combinations.

Controlled laboratory proof press studies showed that the most important printing condition affecting gloss is ink film thickness. The relative gloss tendency of a series of stocks was found to depend on the ink and vice versa; therefore predictions cannot be based on single empirical test measurements. The situation is more complex for coated than for uncoated stocks. The observed trends indicate that gloss holdout depends on a balance between ink setting and the pore structure of the sheet. Clarification of this interaction requires studies of the flow of vehicle from the capillaries developed by the pigment particles in the ink to the capillaries in the stock under the initial influence of ambient printing pressure.

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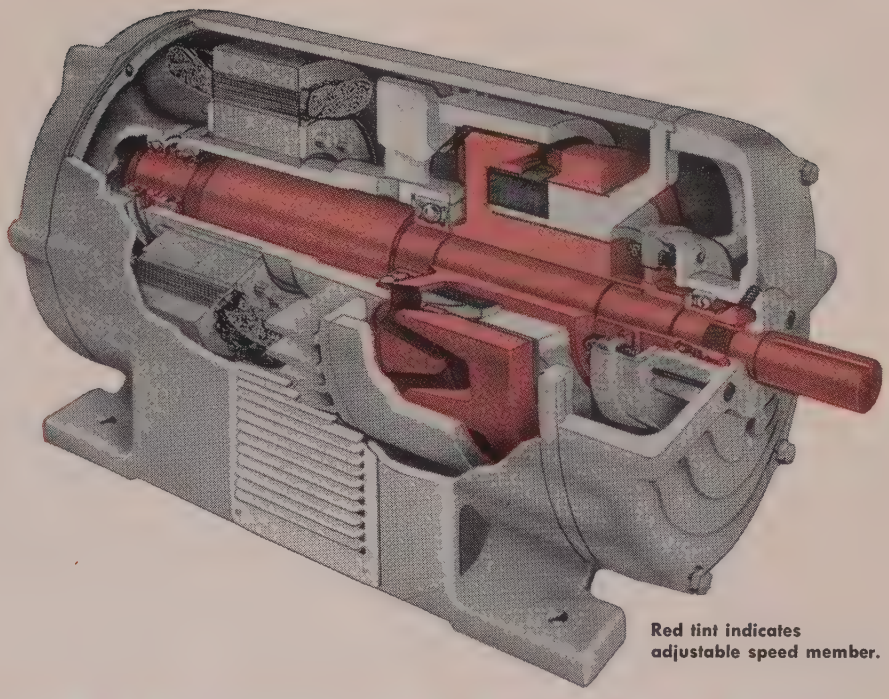
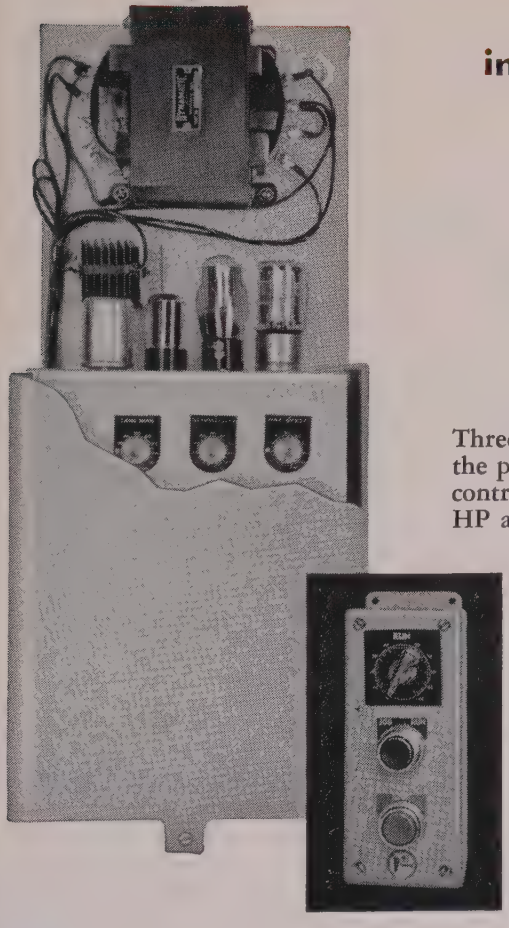


Red tint indicates adjustable speed member.



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Mottle, defined as the nonuniformity of a fully covered print, is highly sensitive to printing conditions; it is enhanced by increasing ink film thickness and pressure and especially by decreasing speed. The most important ink factor is size of the ink filaments during the splitting phase of the transfer process; an intimate understanding of action in the press nip is required to elucide the mechanism. The important paper properties appear to be degree and uniformity of absorption for the particular ink.

3. **The NPIRI Printing Wedge as a Measure of Commercial Printability of Newsprint,** S. Steinberg, New York Times, New York, N. Y., and C. F. Geffken and W. K. Herrmann, J. M. Huber Corp., New York, N. Y.

Relative print qualities of five newsprints printed under actual production conditions and in the laboratory using a modified NPIRI printing wedge were determined. Over-all agreement between the two methods was good as indicated by a correlation co-efficient of 0.934. Within individual panels degree of correlation depended on panel experience in judging production proofs.

A Latin Square experimental design involving five newsprints, five presses, and five runs was utilized in production. The composite of these runs was called a "Master Press Run." In the laboratory white samples were run at five pressures and at a continuous variable film thickness.

Thirteen additional laboratory tests were run on the white samples. These were: Chapman smoothness (glassbacking and rubber backing); ink strike in (Kimberly-Clark); Finnish laboratories E Test and H Test; Bendtsen hardness; Bendtsen smoothness; rotogravure print test; Chandler and Price letterpress test; Bausch and Lomb opacity; PATRA oil test; Ingersoll glarimeter; Bekk smoothness.

The E Test had the best agreement with the Master Press Run; the correlation coefficient being 0.964.

4. **Predicting Paper Printing Quality by the "Battery of Tests" Method,** A. Glassman, R. R. Donnelley & Sons Co., Chicago, Ill.

A method for evaluation and prediction of paper properties important for four-color rotogravure print quality has been determined. This method has been found to apply over a wide range of paper grades covering

1. *Coated* and *uncoated* as well as
2. Wide variations in *pulp furnish* (groundwood and groundwood-free)
3. Changes in finish varying from supered to unsupered.
4. Some papers carbonate filled, others clay filled.

A number of excellent methods are in use that appear to correlate well for a given grade of paper, such as groundwood, machine-coated, or paperboard. These methods appear to work well for a given group of papers made on similar equipment from similar furnishes. Experience has shown no known method could fully explain in numerical fashion why many uncoated papers print smoothly whereas at similar test values coated papers print with such extreme graininess as to be commercially of very poor quality.

This paper describes how, through the cooperation of a group* representing five companies, an inkmaker, and a printer, a precise press trial was made, which together with laboratory work has led to separation of the effects of ink, press, and paper. With respect to paper it was found that *no* single test could explain the observed effects, but that with a battery of as few as four tests an extremely high correlation was obtained. Coefficients of multiple correlation ranging from 0.892 to 1.00 were obtained through the use of a selected battery of tests although in many instances the *individual* tests had very much poorer correlation coefficients, in some cases far below 0.50.

Using an I.B.M. 610 Computer, typical equations were determined, relating laboratory tests with commercial 4C print quality.

Mechanical Pulping Session

1. **New Process for Hardwood Pulping,** H. L. Crosby and N. N. Coe, Dorr-Oliver, Inc., Stanford, Conn.

While investigating the production of chemically-assisted mechanical hardwood pulp, various impregnation procedures were evaluated. Results are presented indicating the advantage of a mechanical compression-decompression technique, such as could be obtained by means of the Haug Kollermill.

The Dorr-Oliver "HiFibre" process was then developed where both chemical impregnation and fiber liberation are accomplished by means of Kollermill followed by a novel screening operation. The process is fully continuous and characterized by a low indicated horsepower requirement.

In addition to cold soda type pulps, the Kollermill action permits the use of a lime slurry as the pulping agent with the advantage of low chemical cost, higher yield, and reduced waste disposal. Comparative data are presented on a number of hardwood pulps prepared in the laboratory and in a semiworks scale installation.

After acquiring rights to the Kollermill, it was redesigned for more reliable, efficient operation. The prototype is being evaluated to obtain an accurate determination of capacity, power consumption, and product quality.

2. **Low Power Cold Soda Pulping,** E. R. Gremler, The Black-Clawson Co., Pandia Div., Middletown, Ohio.

A brief review of the history of cold soda pulping is given. Different cold soda pulping methods are discussed with special emphasis on continuous methods. Pulping data are given on different woods and evidence offered that short impregnation periods and low horsepower are favorable to obtain completely defibered pulp at high freeness.

Power inputs of 9 to 13 hp. per day per ton are reported for the defibering operation when conducted with the Chemifiner—a newly developed, highly density defibering machine. The principle of this machine and its contribution to the low horsepower consumption and improved quality of the cold soda pulp is explained.

Brief mention is made of bleaching cold soda pulp.

Some specific applications of cold soda pulp and the future potential of this pulp in the paper industry are discussed.

3. **Steam Cooking of Northern Hardwoods,** D. A. Feigley and M. J. Showalter, Armstrong Cork Co., Lancaster, Pa.

As controls on a study of pulping of the hardwood species available in northern New York, a series of steam cooks were performed duplicating the conditions assumed to occur in an Asplund type cooker. The cooked woods were evaluated by disintegration through a disk mill and subsequent beating for 1 hr. in a standard Valley beater. Surprisingly, it was found that, with certain species, cooks of 5 to 10 min. at 150 p.s.i. steam pressure produced pulps the equivalent in strength development to fully cooked pulp. The studies indicated that such results could be obtained only with a vapor phase cook and that the strength development correlated with the pH of the cooked chips, the optimum pH for maximum strength development falling about 3.5 $\pm$ 0.2. At higher pH's no such strength development was obtained while lower pH's led to degradition of the base cellulose fibers. It was postulated that organic acids of particular acid strength, either originally present or produced by pyrolysis, were responsible for the unexpected strength developments. This theory was at least partly confirmed by treating wood species unresponsive to the steaming process with selected organic acids, thus causing marked improvements in strength development.

4. **Underwater versus Land Wood Storage and Resultant Effects on Groundwood Pulp,** H. Dailey, Diamond National Corp., Ogdensburg, N. Y.

Studies were made on the pulp brightness, bleachability, and physical properties produced from pulpwood stored on dryland and underwater in both a rough and peeled condition over a two-year period.

The storage conditions had a considerable effect upon the log moisture content, appearance, and weight.

Both the peeled and rough underwater stored wood had unbleached brightness readings that were lower than that of the air stored pulp.

In both land and air storage the peeled wood had a higher brightness than did the corresponding rough wood.

The loss in brightness due to aging was not severe especially with the peeled wood.

On all samples brightness gains due to bleaching were greater after a year and a year and a half storage than they were on fresh cut wood. After two years storage the bleaching response lessened. The rough stored wood had better brightness gains than did the peeled.

The bleached brightness of peeled wood stored underwater for a two-year period was equal to that of the bleached fresh cut wood pulp, while the land stored bleached peeled pulp was slightly higher.

The water storage over a long period increased the pulp Canadian standard freeness. The pulp strengths on all samples were higher after three to six months storage than they were on fresh wood pulp, then they decreased, with the rough stored

* Participating companies: Ink and test facilities—In Tag Division of Interchemical Corp. Several papers supplied by each: Mead Corp., The Mead Corp., Consolidated Water Power & Paper Co., St. Regis Paper Co., Provincial Paper Ltd., and Kimberly-Clark Corp. Printer: R. R. Donnelly & Sons Co. In addition some European paper was included in this test, courtesy of R. R. Donnelley & Sons.

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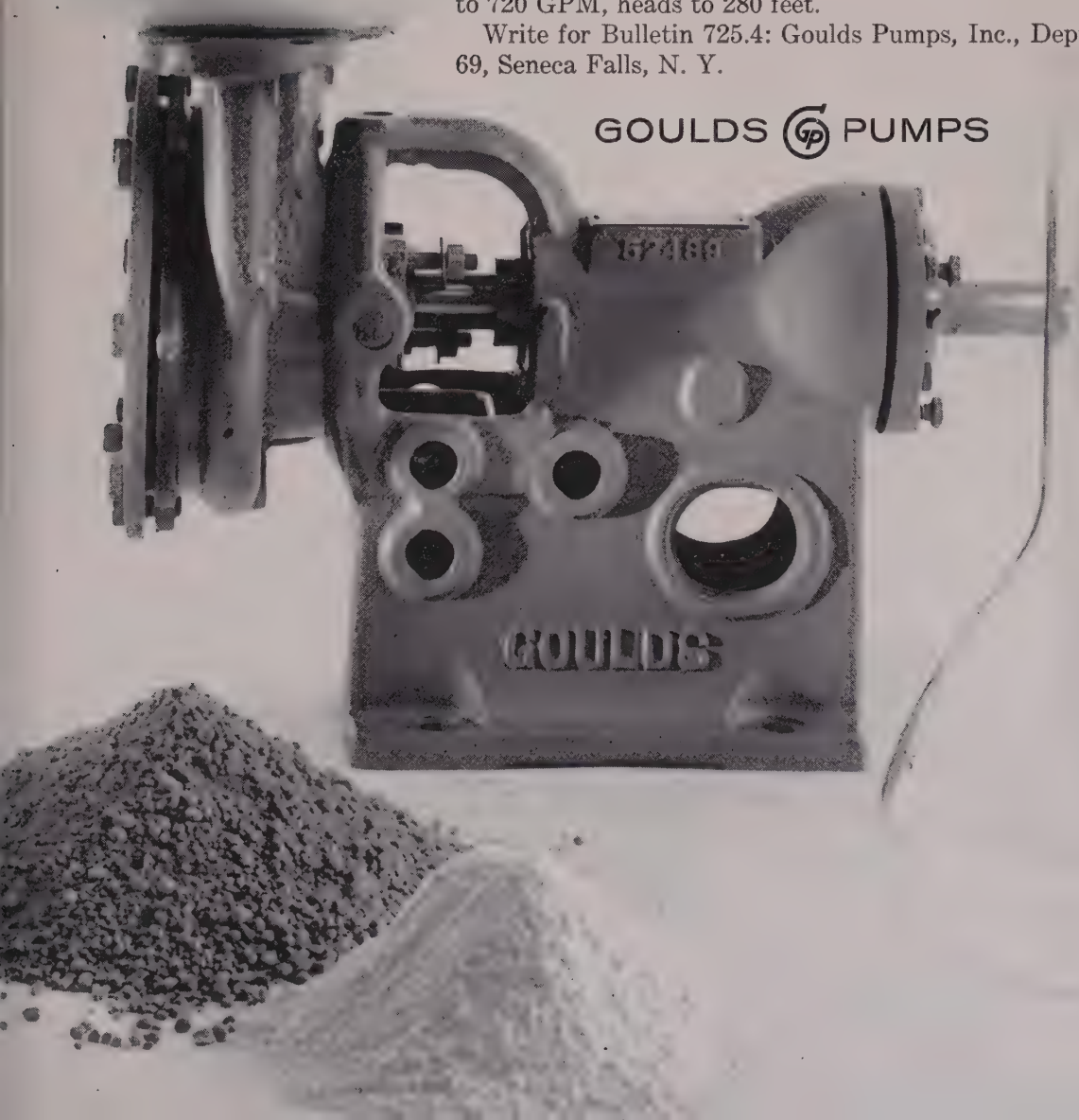


wood being reduced at a greater rate than did that of the peeled stored wood pulp.

The benefits of peeled wood in either storage condition are evident while underwater storage does not appear to be of any greater value than dry land storage.

Dissolving Pulps Session I

1. **Xanthate Sulfur Determination by the Batch Ion Exchange Method,** L. H. Phifer and J. L. Bell, American Viscose Corp., Marcus Hook, Pa.

A procedure has been developed for xanthate sulfur in viscose based on batch ion exchanging to remove the by-product sulfur compounds and subsequent determination of the xanthate group by ultraviolet spectroscopy. There is a considerable improvement in the time required for an analysis over the existing methods in the literature. The precision of the method is sufficient to significantly measure the differences which occur as a result of aging viscose two hours.

Comparative data indicates that results by the new method are more precise and in good agreement with the other methods available.

2. **Rapid Method for Determination of Total Sulfur in Viscose,** J. F. Crow, J. P. Dux, and L. H. Phifer, American Viscose Corp., Marcus Hook, Pa.

A method for determination of total sulfur in viscose is described in which oxidation of the sample by combustion in a stream of oxygen at 1400°C. is used to convert all of the sulfur to the dioxide, which is then oxidized to sulfate by passing the effluent gases through a solution of hydrogen peroxide. Sulfate is determined by titration with barium perchlorate in a water-isopropanol solution, using Thorin as an indicator. The method requires approximately 30 min. for a duplicate determination, has a standard deviation of 0.016% S, and comparison with the gravimetric sulfate method shows no significant deviation with regard to accuracy.

3. **Cord Fatigue in Fleet Tested Tires,** W. G. Klein, M. M. Platt, and W. J. Hamburger, Fabric Research Laboratories, Inc., Dedham, Mass.

This is a progress report on a continuing research which is aimed at delineating the nature of cord fatigue in tires run under normal conditions. The first stage of this study deals with the properties of cords and filaments removed from tires run on a New York taxi fleet, and includes usage up to 100,000 miles. The major emphasis was on tires constructed on Tyrex viscose cord, but corresponding studies were also made on a smaller group of nylon cord tires. Some previous work on this problem indicated that a linear degradation of cord tensile strength with mileage might be anticipated, and, implied that the rate of change of cord tensile strength could be taken as a measure of fatigue resistance. The current studies performed on the tires from this test indicate that: (a) there is an initial loss of cord strength of about 10 to 15%, occurring within the first 20,000 miles, followed by a long period of very gradually diminishing strength, (b) while there is a trend for a small loss in fiber strength with mileage, it is not correlative with cord strength losses, (c) the strength loss in the few severely weakened cords found was attributable to filament breakage, (d) no unusual strength losses were observed in intact cords from tires classified at fatigue failures. Some observations on the role of adhesion, pertinent to the problem, are presented.

4. **Structural Changes During Aging of Alkali Celluloses,** K. H. Lauer, University of Alabama, University, Ala.

Analyses of rate of drying curves of celluloses, regenerated from alkali celluloses at varying stages of aging showed differences in lateral order behavior for cotton linters, sulfite, and prehydrolyzed sulfate wood pulps. These differences were not observed with each type of wood pulps originating from softwoods or hardwoods. It is therefore the process which determines the character of viscose grade dissolving pulps and not the wood species used. It is also during the digestion, that the character of the pulp is established and not the bleaching step.

There is a slight indication that the slopes of the semilog rate of drying curves show differences in filtrability but only for the same types of pulps.

X-ray diffraction measurements indicate the same periodic pattern of lateral order changes with aging progressing as drying curves, desorption ,regain, and sedimentation volume.

Statistics Session I

1. **The TAPPI Statistics Committee Attributes Sampling Program,** W. E. Carlson, St. Regis Paper Co., Carthage, N. Y.

2. **What Use Is Statistics to Me?,** P. C. Clifford, Montclair State College, Montclair, N. J.

3. **Simulation of Pulpwood Inventory Dynamics,** T. A. Hewson, St. Regis Paper Co., New York, N. Y.

A pulpwood inventory will fluctuate in size because of uncontrollable variations in production, weather, labor, transportation, the availability of stumpage and other factors. The size of a pulpwood inventory at any time should be large enough to tolerate subsequent variations downwards without running out of wood. On the other hnad it is impractical to carry an inventory large enough to guarantee a supply of wood under catastrophic circumstances. A pulpwood inventory should properly be proportional to the risk which management is willing to accept in the face of uncertainties in procurement and production. The risks associated with different size pulpwood inventories have always been difficult to evaluate and express in meaningful terms.

A pulpwood supply and demand situation is simulated by means of a mathematical model. Uncontrollable elements of the complex are replaced by probability distributions. The model is programmed for a computer and simulated operational data are obtained for extended periods of real time. The nature and extent of inventory fluctuations are investigated. The model is altered to test the response of different inventory policies, production levels, and procurement procedures. The risks associated with various operating policies and procedures are quantified.

Plans have been made for those attending this session to see the actual problem being run on a high-speed digital computer at another location, immediately following the author's presentation.

Graphic Arts Session II

1. **A New Method of Finishing Coated Paper,** F. H. Frost, S. D. Warren Co., Cumberland Mills, Me.

A process is described in which typical, mineral coated surfaces, suitable for printing purposes, are raised to high finish levels without the brutal effect of calendering.

The uncalendered coated surface is finished by passing it through a low-pressure nip under particular conditions of such factors as temperature, pressure, and moisture.

The method is designed to maintain bulk, opacity, brightness, and resiliency. The process also offers an opportunity to diminish the waste and defects which are normally associated with calendering.

Pulp Purification Session I

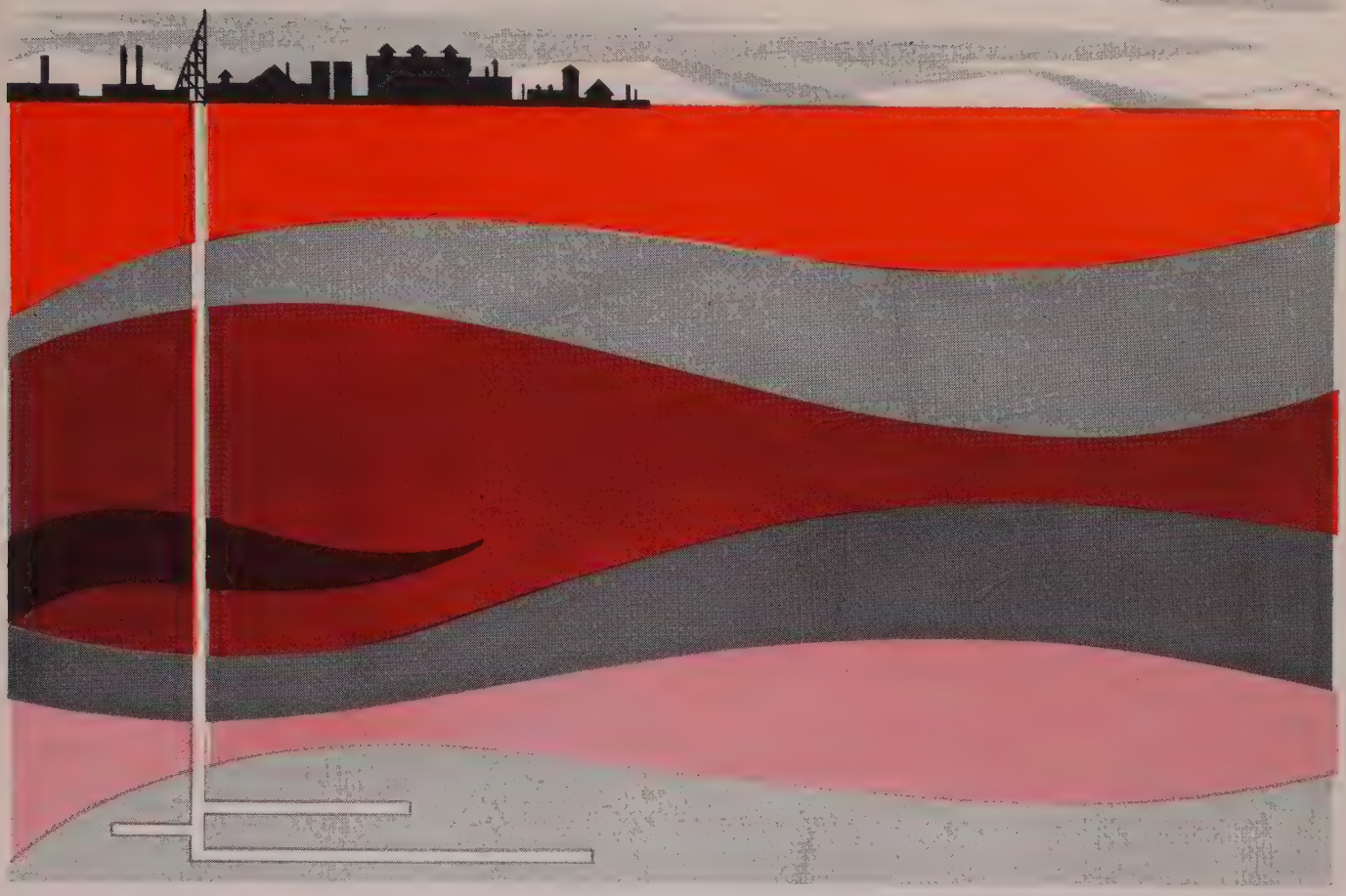
1. **A Study of the Hot Alkaline Degradation of Carbohydrates by Means of Ultraviolet Absorption,** D. E. Rivington and H. Kraessig, Industrial Cellulose Research, Ltd., Hawksbury, Ont., Canada.

The hot alkaline extracts from cellulosic materials have an ultraviolet absorption maximum at 288–290 millimicrons, which is shifted to about 253 millimicrons on acidification. Identical spectra were obtained from the reaction of cellobiose with hot alkali, showing that the carbohydrate fraction, and not residual impurities, gives rise to the formation of products having these UV absorption bands. Related experiments have indicated that only the hot alkaline treatment of 4-0-substituted reducing hexoses produces solutions with these spectral characteristics. Simple hexoses such as glucose did not yield solutions with these properties.

The compound responsible for these UV absorption bands was removed from the alkaline solutions by anion exchange resins, and has been isolated subsequently in reasonable purity by elution with acidified methanol. This substance has been tentatively identified as 1-methyl cyclopentane-2,3-dione, as suggested by Enkvist. Later eluates from the same anionic column show that one, or possibly two, further compounds which absorb in the ultraviolet can be obtained from these solutions or extracts.

2. **The Effect of the Hypochlorite Bleaching Variables on Prehydrolyzed Sulfate Hardwood Pulp Properties,** J. W. Smith and W. L. Thornburg, Buckeye Cellulose Corp., Memphis, Tenn.

The effects of five hypochlorite bleaching variables on the chemical properties of prehydrolyzed sulfate hardwood pulps were investigated by means of a five-factor orthogonal second order composite design. The single replicate of 27 experiments, sufficient to detect linear effects of the magnitude of one standard deviation, was made to determine the influence of temperature, time, per cent available chlorine, starting pH, and incoming



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viscosity in the hypochlorite bleaching stage on the resulting pulp viscosity, Swedish solubilities and steeped pulp color.

Data, collected for each experiment following the hypochlorite stage and also for the finished pulp, were statistically evaluated. The results of the statistical evaluation of the data for the various pulp properties are presented in the form of mathematical equations.

Examination of values obtained from the calculation of the various equations permits the following observations.

1. Starting pH is by far the most important variable in the hypochlorite bleaching stage, since it is the only variable affecting every pulp property at the 99% confidence level.
2. Temperature and per cent available chlorine appear to be nearly equal in their effect on the various pulp properties.
3. Time has considerably less effect than do any of the three variables above, with the incoming viscosity having the least effect.
4. The Swedish solubilities of the unbleached pulp appear to pass through a maximum when approximately 19.5% active alkali is used in the sulfate cook, and these solubilities do not appear to change greatly during the subsequent bleaching treatments.

3. Demethylation of Aromatic Methyl Ethers and Its Relation to Chlorination of Lignin and Wood Pulps, R. W. Strauss and K. V. Sarkanen, New York State College of Forestry, Syracuse, N. Y.

Research on various model compounds has demonstrated that the demethylation of lignin by chlorine is a molecular chlorine catalysed hydrolysis to methanol and a free phenolic hydroxyl group. It is not an oxidative process as was assumed previously.

The rate of demethylation of chloro derivatives of aromatic methyl ethers is dependent upon the number and position of the chlorine substituents in the aromatic portion. 4,5 Dichloroveratrole demethylates rapidly, 3,4,5, trichloroveratrole slower, and 3,4,5,6 tetachloroveratrole at an extremely low rate. 2,4,6 trichloroanisole does not demethylate.

The significance of these reactions for the chlorination of lignin and wood pulp is shown, especially in regard to color formation and subsequent removal by washing or alkaline extraction.

Dissolving Pulps Session II

1. The Oxidation of the ICCA Pulps with Lead Tetraacetate, Richard W. Detrick, Thilmany Pulp and Paper Co., Kaukauna, Wis.

An investigation was made in order to extend the work initiated by Steinmann and White who suggested that mannose units in wood pulps were selectively oxidized by lead tetraacetate in glacial acetic acid. The effects of temperature and concentration were investigated and the eight ICCA pulps then were oxidized under more drastic conditions than those employed by Steinmann and White. Analyses of the oxidized pulps showed that a selective removal of mannose units took place during the oxidation. In addition, a smaller but significant, removal of xylose units was found (thus confirming the work of Foudier and Nick). The importance of the degree of polymerization and the accessibility of the pulps was investigated and found to have an influence secondary to that of the mannose unit content of a pulp. Erythrose, the ultimate degredation product of a 2,3-glycol oxidation of a hexose unit, was identified in a hydrolyzate from the oxidized pulp. Analyses of the oxidation solution and determinations of yield supported the postulate that the mechanism of the sugar removal was not oxidation alone but rather an oxidation followed by a limited hydrolysis or solution of the sugar units in the more accessible portions of the oxidized pulp.

2. Chemical and Physical Nature of Insolubles: Acetone Solutions of Cellulose Acetate, L. H. Sperling and M. Easterwood, Buckeye Cellulose Corp., Memphis, Tenn.

An examination of the chemical and physical properties of gels in wood and linters cellulose acetates was carried out with special emphasis on light-scattering and electron microscopy. Gels were fractionated by filtration, centrifugation, and dialysis techniques to produce gels over and under 15 microns in size.

The predominant phenomena observed in the small gels are nearly monodisperse sphere- or potato-shaped gels of about 0.9 micron in dispersion (light-scattering) and 0.1 micron dry (electron microscopy). Chemical analysis shows these gels much enriched in xylan.

The large gels were examined also and were found to be fibers (cellulose-I) and plates (cellulose triacetate).

3. Dissolving Pulps from Domestic Timber Bamboo—*Phyllostachys bambusoides,* T. R. Naffziger, T. F. Clark, and I. A. Wolff, Northern Regional Research Laboratory, Peoria, Ill., and R. W. Matuszewski, Buffalo, N. Y.

Dry, mature, timer bamboo—*phyllostachys bambusoides*—was investigated as a raw material from which to prepare dissolving-grade pulps by prehydrolysis, sulfate-pulping techniques. The condition of the raw material and the variables in the hydrolytic treatment were studied for their influence upon yield and characteristics of the pulps when pulping and bleaching conditions were kept constant. Nitric acid, steam, and water were used as the hydrolytic agents. Pulps obtained under a number of combinations of variables had chemical and physical characteristics in the range of those of commercial cellophane, textile, and medium-tenacity grades of dissolving pulps from woods. One satisfactory hydrolytic technique involved cooking bamboo chips, collected between screens with $^1/_2$- and $^3/_4$-in. diam. openings with 6% nitric acid (basic chips) at 140°C. for 30 min. Hydrolyses with steam water at 180°C. gave comparable yields and properties, except that the disperse viscosity was lower. Yields of pulps ranged from 23 to 32%. Further evaluation of bamboo pulps by actual conversion to viscose-derived products appeared warranted.

Statistics Session II

1. Some Underlying Considerations in Estimating Basis Weight and Basis Weight Variation, M. S. Renner, Dewey & Almy Chemical Div., W. R. Grace & Co., Cambridge, Mass.

2. Basis Weight Variation from the Consumer's Point of View, D. Looney, Polaroid Corp., Cambridge, Mass.

3. Basis Weight: Can We Control It?, F. C. Hartwell, Peter J. Schweitzer Div., Kimberly-Clark Corp., Lee, Mass.

If a reasonably stable process exists, with control over sampling, test equipment, and testers, and good decision-making on the part of the machine personnel prevails, then basis weight should be able to be controlled.

It is not too difficult to define sampling and testing procedures, and to establish effective audit systems. It is a much greater problem to improve the decision-making and to provide a reasonably stable process. Manufacturing control limits for basis weight, calculated from residual sigma and which include little more than testing errors and the inherent variability of the grade being manufactured, provide good information for determining when a gate adjustment should or should not be made. Control charts are also often helpful as they provide a picture of shifts of basis weight from target levels.

Manufacturing service groups can be helpful, through cooperative effort with machine and supervisory personnel, in seeking out and correcting the cause of unacceptable shifts in basis weight levels.

This paper includes the development by statistical methods of manufacturing control limits for basis weight control in both machine and cross-machine direction. Also described are a number of process studies where basis weight variations were detected and reduced to acceptable levels.

4. A Statistically Based Sampling Procedure for Estimating Conformance to Basis Weight Specifications, J. H. Moyer, The Champion Paper and Fibre Co., Texas Div., Pasadena, Tex.

Acceptance of a reel of paper or board implies that the product conforms to specifications throughout the entire reel. Of necessity, the decision to accept invariably depends on samples. Unfortunately, such decisions carry a risk of accepting a reel in which a proportion of the product is outside of specifications even though the sample is not. The paper suggests a method for estimating the magnitude of basis weight variability within a reel, and the respective contributions of machine and cross direction variation. The way in which this variation can affect the ability of a sample to truly represent the entire reel, and the design of an acceptance sampling plan based on knowledge of the within reel variability is described. An acceptance sampling plan specifies the number of samples to be tested and an "acceptance limit" to which the sample average must conform. It is shown how this limit depends on a compromise between the twin risks of accepting reels in which an unsatisfactorily large amount of paper outside of specifications or of rejecting reels which could satisfactorily meet the customer's specifications. It is made clear that acceptance limits are not likely to be as wide as specification limits.

Dissolving Pulps III

1. The Swelling and Dissolving of Plant Fibers in New Dissolving Agents, G. Jayme and M. Harders-Steinhauser, Institut für Cellulosechie, Darmstadt, Germany.

This film intends to contribute to the understanding of the fine structure of cellulose fibers and of their reactivity, observed at the dissolution of the fibers in the new solvents Cadoxen

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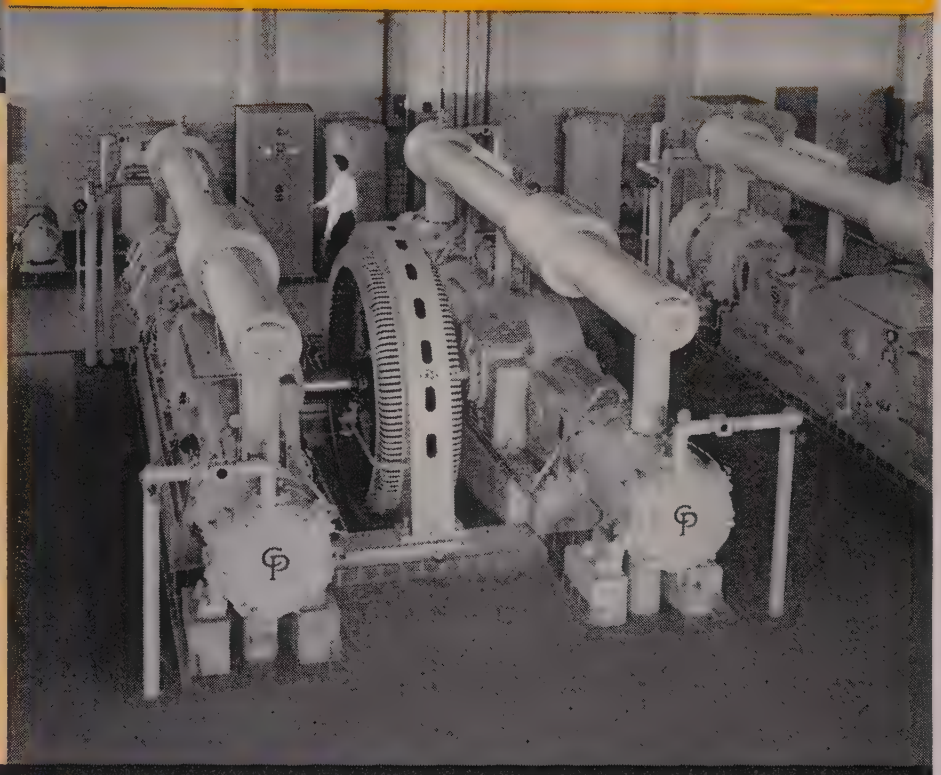

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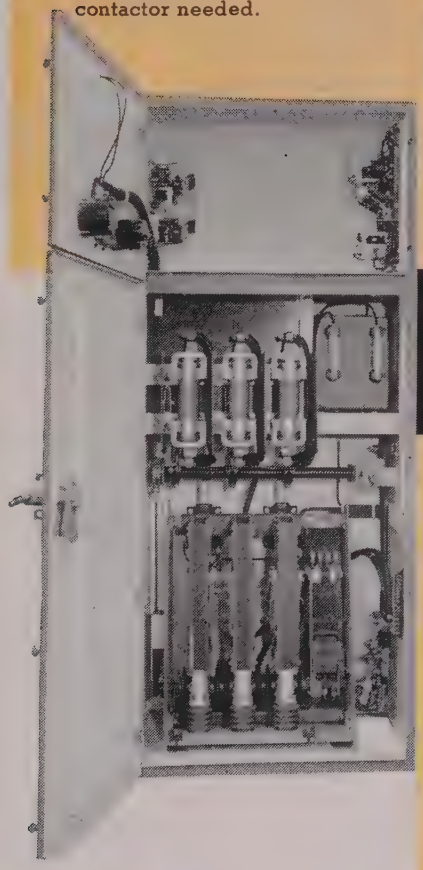

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([Cd (en)$_3$] (OH)$_2$) and EWNN (sodium-iron-tartaric acid). The dynamics of the swelling and dissolving procedure, which were already earlier described and their effects are shown in many scenes in the "living" picture. Here the cell wall S_1, winding in flat helix structure around the fiber exerts a very pronounced disturbing influence.

As long as it is not weakened, this fiber wall is responsible for the well-known balloon formation ,shown here with raw cotton, Manila hemp fiber, pine and spruce pulps. It is also responsible for the secondary formation of "press-disks," the delayed solution of which could be photographed. In case that the secondary wall S_1 is rather weak, the fiber disintegrates into spindle shaped aggregates during the dissolution. In case of highest reactivity the fiber "melts" without the formation of intermediate structures becoming visible in the light microscope. Transitions between these extreme cases are shown as well as the torsion of the fibers and their shrinkage in longitudinal direction during dissolution. Another section deals with the different effect of the two applied new solvents Cadoxen [4.87% Cd and 31.2% (en)] and EWNN (390 g.p.l. complex 2 *N* NaOH) and the formation of intermediate forms differing from each other. EWNN acts slowly but effectively over glassy intermediate forms of a strongly widened rest structure. Cadoxen on the other hand attacks quickly, makes visible the fine helical stripes of the swollen secondary wall S_2 and is evidently not able to dissolve parts of the fiber having an exceptional high DP. The general importance of these observations for the dissolution of cellulose is evident.

The biological differences between spring and summer wood fibers could also be shown cinematographically. Spring wood fibers, dissolving very quickly, are simultaneously shown besides summer wood fibers, which only dissolve slowly or partly. The natural differences between the two fiber types are not or only partly compensated at the technical production of pulps by the digestion and bleaching procedures. It is shown that these differences are still prevailing even in rayon pulps of high reactivity and that they still may play there a disturbing role. The last scenes of the film show the ideal case of the highly reactive spring wood fibers with wide lumen and relatively thin cell wall. All photographs were taken from fibers which could move freely so that the observed events could proceed in a "true" fashion.

2. **Electron Microscopical Studies of Alterations of Fiber Structure Effected by Swelling,** G. Jayme and G. Hunger, Institut für Cellulosechemie, Darmstadt, Germany.

It has been tried to study swollen softwood fibers by electron microscopy while still in the state of swelling and without drying. Electron micrographs can only be obtained by producing a thin matrix of the object as the electron rays only will penetrate layers up to about 500 A units thick. The preparation of metal carbon replicas of the swollen fibers has to overcome the difficulty, that the swollen fiber loses water in the high vacuum of the evaporating apparatus. Some of the (en)-complexes and the sodium iron-tartaric-acid complex recently developed by Jayme and co-workers were found to be stable enough to leave the fibers still in a fairly high state of swelling at the high vacuum of the metal shadowing apparatus. A mixture of phosphoric acid and glycerol had the same effect. From specimen treated with these swelling agents carbon-metal replicas could be prepared and observed in the electron microscope. It is shown that dried pulp fibers, especially the wide lumed spring wood fibers, mostly will collapse during drying and that some of the former fiber edges will appear as rather flat elevations on the fiber in longitudinal direction. These places will have to endure the smallest swelling pressure during the swelling process. At the same places bundles of microfibrils in fiber direction have been found on the swollen fiber, which apparently have been part of the primary wall. Other electron micrographs indicate the state of the outer cell wall layers during the swelling. The beginning of a balloon swelling is shown which starts at places where the outer layer of the secondary wall has been damaged. Some specimens were treated with a mixture of phosphoric acid and glycerol, revealing or leading to a periodical substructure of the microfibrils. Finally, a sample swollen in concentrated phosphoric acid was quickly washed with water and then replicated. In this case parallel lying structures become visible, which probably have to be regarded as secondary structures, resulting from a recombination of cellulose chains.

As a whole, these investigations prove that with a new and improved technique it is possible to follow up large and small alterations of cellulose fiber structures and their surfaces by means of electron microscopy in a swollen and undried state of the fiber.

Pulp Purification Session II

1. **Oxidation Potential for Control in the Bleach Plant,** A. D. Harbin, Jr., Diamond Alkali Co., Painesville, Ohio.

The Diamond chlorination cell is currently in use as a means

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of controlling bleach liquor production and pulp chlorination. The cell is composed of platinum and silver electrodes that are cast in a resin body of sturdy design for easy installation. A technical bulletin is available giving a full description of the cell.

A brief description of the cell development is outlined. General acceptance in a large number of pulp mills is discussed.

From field experience, installations are described and data are presented to explain successful use of the cell in different mills. Examples are reported in which the chlorination cell is used both in bleach liquor make-up and pulp chlorination.

2. **Use of Titanium in Pulp Bleaching Equipment,** G. W. Bauer, Mallory-Sharon Metals Corp., Niles, Ohio.

The important physical and mechanical properties of titanium are presented, along with a brief description of its extractive metallurgy, melting, welding, fabrication, and mill products available.

The rapid growth of chlorine dioxide bleaching and the severe corrosion problems resulting from this process are discussed. It is mentioned that, until titanium had been utilized, no metal was completely satisfactory for chlorine dioxide bleaching equipment. The corrosion resistance of titanium in chlorine dioxide solutions, or gas, is excellent. The inherent characteristics in titanium which affect its corrosion resistance are mentioned.

Titanium has been used in several applications in chlorine dioxide bleaching. Some parts have been in service for almost six years with no apparent corrosion. Increased usage of titanium is predicted because of steadily decreasing prices and increasing knowledge of its corrosion resistance.

3. **Refiner Bleaching of Cold Caustic Pulp,** J. F. Jahne, Diamond National Corp., Ogdensburg, N. Y.

A system for bleaching cold caustic hardwood chips is described wherein the bleaching chemicals are added to the chips as they enter the primary double disk refiner. Applying 2.5% H_2O_2 50%, 5.0% sodium silicate and 0.47% NaOH on an oven-dry pulp basis in this way, gave a brightness of 60 from an unbleached brightness of 42. This result was obtained after the chips had passed through two refiners and after the treated pulp was held a maximum of four hours in a chest under the secondary refiner.

Applying the same chemicals in a more conventional batch type bleaching system gave a brightness of 58. It is concluded, therefore, that refiner type bleaching gave better results than the batch type. It is also shown to be adaptable to existing equipment and does not require addition of special mixers or bleach towers.

4. **A Review of the Continuous Production of Hypochlorites in the Paper Industry,** I. C. MacGugan and R. C. Ericson, Wyandotte Chemicals Corp., Wyandotte, Mich.

The continuous manufacture of hypochlorite solutions as recommended for use in the pulp and paper industry is reviewed. One system for producing sodium hypochlorite solution continuously is discussed in detail. The advantages to be obtained by the use of a continuous system as contrasted to the batch system are uniformity of product, reduction in operating space requirements and reduced labor costs.

Corrosion Session

1. **A Review of Corrosion Problems in Neutral Sulfite Semichemical Pulping,** E. K. Scholz, West Virginia Pulp and Paper Co., Covington, Va., and L. H. Park, Union Bag-Camp Paper Corp., Savannah, Ga.

The erosion-corrosion problems of neutral sulfite semichemical pulping are different than kraft, acid sulfite, or cold soda. Digesting is done in one of three ways—rotary, stationary or continuous digesters. Defibering is done before and after blow tanks by single-disk, double-disk, or combination refiner-washer. Washing is done by drum washers, screw press, or combination refiner-washer. Different type pumps are used, depending on mill experience. In the final analysis, "metal-losing" control depends upon the choice of construction materials, not only from the standpoint of chemical attack, but combinations of corrosion and erosion. In the latter case, it has been sometimes found that these are complementary; one type of corrosion would not be found if erosion were not present.

2. **Alkaline Pulping Corrosion Problems,** W. E. Hendricks, The Mead Corp., Chillicothe, Ohio, and W. C. Barnwell, Gaylord Container Div., Crown-Zellerbach Corp., Bogalusa, La.

3. **The Influence of Composition Balance and Control of Cast Stainless Alloys Designed for the Pulp and Paper Industry,** J. M. Wilcox, W. R. Barber, Jr., and D. D. Burgan, Electric Steel Foundry Co., Portland, Ore.

The 18–8 series stainless alloys are standard for many applications in the pulp and paper industry. This paper discusses the development of these alloys and introduces several new improved stainless alloys which it is anticipated will be used in the future for those applications requiring a better specific or combination of properties than those heretofore available from the standard stainless alloys.

The importance of composition balance is also discussed and its effect in various pulping processes is illustrated. The importance of molybdenum content is stressed.

Metallurgical advancements of recent years in the control of melt analyses is briefly discussed. The results of advancement in control procedures on the improvement in service performance as well as the ability of stainless alloys produced under these control procedures to satisfy more stringent service requirements is shown.

General Session II

1. **Dispersion of Asphalt Materials in Paper Stocks by the Petro-Diffusion System,** L. Van Guelpen, The Black-Clawson Co., Middletown, Ohio.

2. **Pulping Process Studies. I. Aspects of an Integrated Nitric Acid Pulping Process,** D. L. Brink, University of California, Richmond, Calif.

Conditions relating to pulping in the State of California are considered. Amount, location, and species of wood available as a potential raw material is reviewed. The availability and characteristics of water as a resource and the bearing upon pulping in the state are briefly outlined. Consideration of the fiber and water resources in relation to the extensive lumbering, agricultural, and industrial activity of the area and the pressures exerted by a rapidly expanding population present a peculiar set of conditions and requirements which indicated that design of a pulping process to satisfy this particular situation might have merit. A review of the nitric acid process is given outlining basis for selecting it for initial studies. A modification involving extraction with ammonium hydroxide was envisaged which it is suggested will permit a design taking advantage of the particular situation which exists. A flow diagram of the process is presented with certain steps indicated where new information is critically needed.

3. **Pulping Process Studies. II. The Two-Stage Nitric Acid: Ammonium Hydroxide Process and Evaluation of Effluents as Fertilizers,** D. L. Brink, J. Vlamis, and M. M. Merriman, University of California, Richmond, Calif.

The study carried out to establish procedures and conditions for the preparation of effluent materials to be studied as fertilizers is described. Yields of pulp, effluent solids, and gases obtained in the reactions are given as functions of time at reflux temperature and initial nitric acid concentrations of 9% using 100% HNO_3 on the wood basis. Limited results are given in which green sapwood and green heartwood of white fir are used in place of air dry chips from a mixture of sapwood and heartwood. Methods devised for analysis of effluents and gases evolved are noted. Results obtained in reactions scaled-up for the preparation of effluent solids are presented.

Methods used in the evaluation of the effluent materials as nitrogen supplying fertilizers and results obtained are given. It is demonstrated by pot culture tests that the materials are essentially as effective as would be indicated by their nitrogen analyses which range from 10 to 26%. No untoward or toxic effects of these materials were detected with respect to plant growth. These results supply information on one aspect which is considered crucial in the design of the integrated nitric acid process.

4. **Crown Control of Paper Calenders,** M. D. Stone and A. T. Liebert, United Engineering & Foundry Co., Pittsburgh, Pa.

This paper discusses the problems of obtaining the proper total crown for varying nip pressures, temperatures, speeds, etc., and focuses attention on a new development in the field of paper calendering. This development places in the hands of the operator, the ability to vary the crown of the king roll (and also the top roll—independently) practically over the full range, as different types of products with varying requirements as to loading, etc., are calendered.

The method is to bend the king roll (or the top roll) by an hydromechanical system, which can be varied practically instantaneously, as desired. This technique has been in successful use for several years in rubber calenders by the Adamson-United Co., a subsidiary of United Engineering & Foundry Co.

In addition, the paper will give equations for determining total

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crown, and formulas for required "true" crown, including the contribution of shear to roll deflection, and a description of how such true crown curves, i.e., crown shape, as contrasted to center magnitudes only, can be obtained by grinding with adjustable partial-cosine-curve crowning attachments.

5. **A Proposed Test for Abrasiveness of Pigments and Paper Fillers,** R. D. Fraik and F. C. Schultz, The New Jersey Zinc Co. (of Pa.), Palmerton, Pa.

Wear of paper-producing and converting equipment is receiving greater attention because of its economic importance. A significant factor related to wear of fourdrinier wires, printing plates, and trimmer blades is that of abrasion associated with paper loading materials. Previous approaches to this problem have been for specific applications and a procedure capable of broad application in relating mill experience is needed. This paper proposes a method which may have such broad application. Data are presented covering six typical materials. In addition, some study of test variables is covered including the effect of alum. While further refinement and standardization is needed, the procedure has been useful.

Drying Session

1. **An Optimized High Velocity Air Drier,** R. A. Hurm, Beloit Iron Works, Beloit, Wis.

The use of the high velocity air drier on paper surface to accelerate drying rate represents the most recent technological inroad to the drying problem in years. Application of the high velocity principle to drying of sheet coating, starch solutions after calender water boxes, size applications, as an assist to cylinder drying, Yankee driers, etc., is just now gaining momentum. A new application of this drying principle is aimed in the direction of cross-machine moisture profile correction with a view to improving sheet finish, supercalendering, etc., as a result of being able to carry higher reel moisture.

Air drier performance should be evaluated on the basis of heat transfer coefficient obtainable with a given expenditure of blower horsepower. Since drying rate is a function of the heat transfer coefficient "*h*" obtainable with a given weight of air at a given velocity and temperature, the target of developing a configuration to produce the best "*h*" with least horsepower is a worthwhile one. Dimensional stability, features conducive to good papermaking, as well as sheer day-in day-out operating ruggedness are considered in this air drier design.

2. **Heat Transfer and Water Removal in Cylinder Drying. Part I. On Unfelted Cylinders,** A. H. Nissan, Rensselaer Polytechnic Institute, Troy, N. Y., and D. Hansen, Union Carbide Nuclear Co., Tuxedo, N. Y.

In earlier papers a theory was presented for describing the transfer of heat and evaporation of water on a cylinder drier. Approximate solutions for the equations were also presented, together with an example of their application to some calculations on an industrial machine.

Exact numerical solutions for the theoretical equations have now been obtained and verified by comparison with experimental measurements. The results of these experiments have also allowed a detailed look at the mechanisms of water removal, and the factors controlling transfer of heat on a cylinder drier.

The temperature distribution within the sheet at different times is predictable. Water is removed not only by evaporation from the sheet but also, when the sheet is very wet, by participation onto the cylinder followed by evaporation.

Felted cylinders are not discussed; they will form the subject of future studies.

3. **Low Temperature Radiant Heat Drying,** H. L. Smith, Jr., Horace L. Smith, Jr., Inc., Richmond, Va.

Substantial increase in drying capacity of paper machines can be obtained by the application of low-temperature liquid heated radiators. Many materials, including paper, absorb radiant heat almost perfectly when heat is radiated in the long wavelength band (4 to 8 microns) but absorb very little radiant energy in the short wave-length band. The Smitherm process consists of thin lightweight sheet metal radiators having a highly emissive surface. The radiators are curved and mounted in a fixed position on the paper machine, with the radiating surface spaced from 2 to 6 in. from the sheet.

A high boiling point, nonvolatile, nonflammable, noncorrosive liquid heat transfer material is heated and circulated through the radiators at practically atmospheric pressure. Approximately $1^1/_2$ lb. of water can be evaporated per square foot of radiator surface per hour. The cost per pound of water removed is substantially lower than by conventional steam driers.

Installation of the equipment can be made with practically no shutdown time.

The liquid heater can be located several thousand feet from the machine with neglectable loss in transit. Fuel can be coal, oil, or gas.

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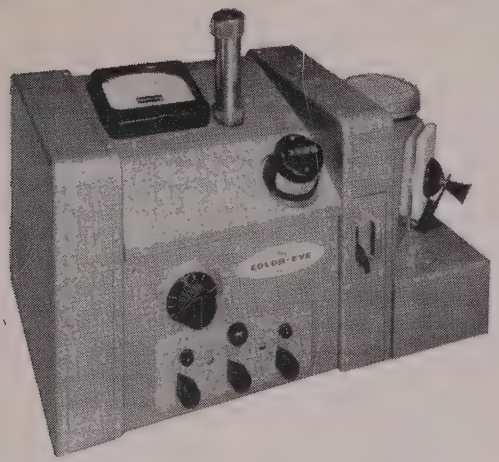

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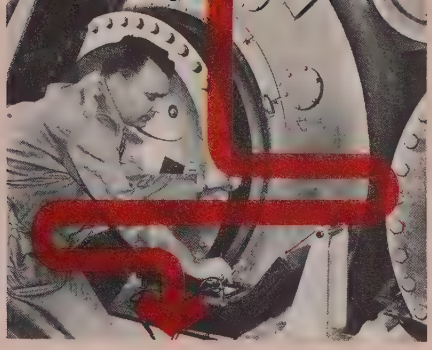

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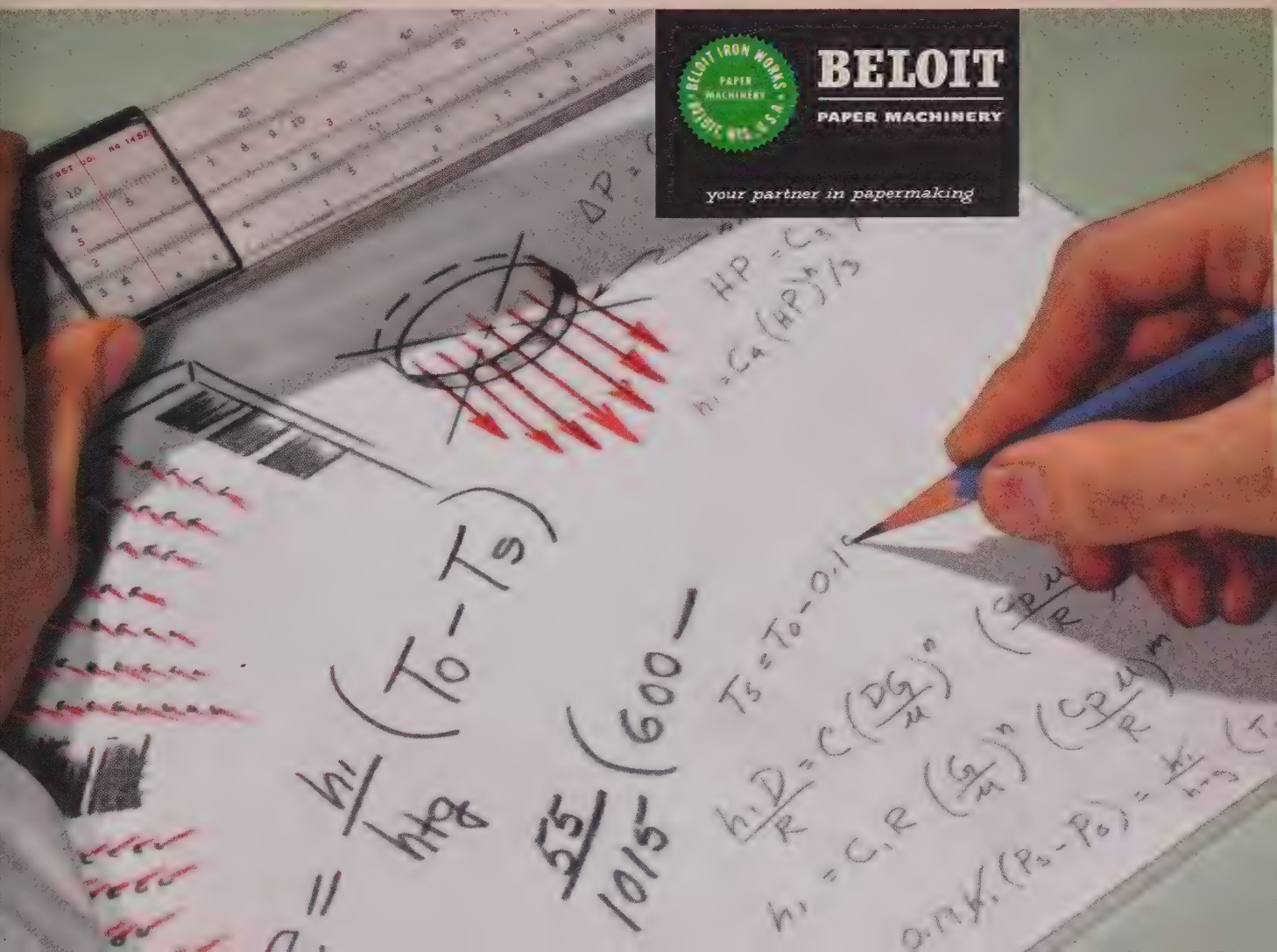

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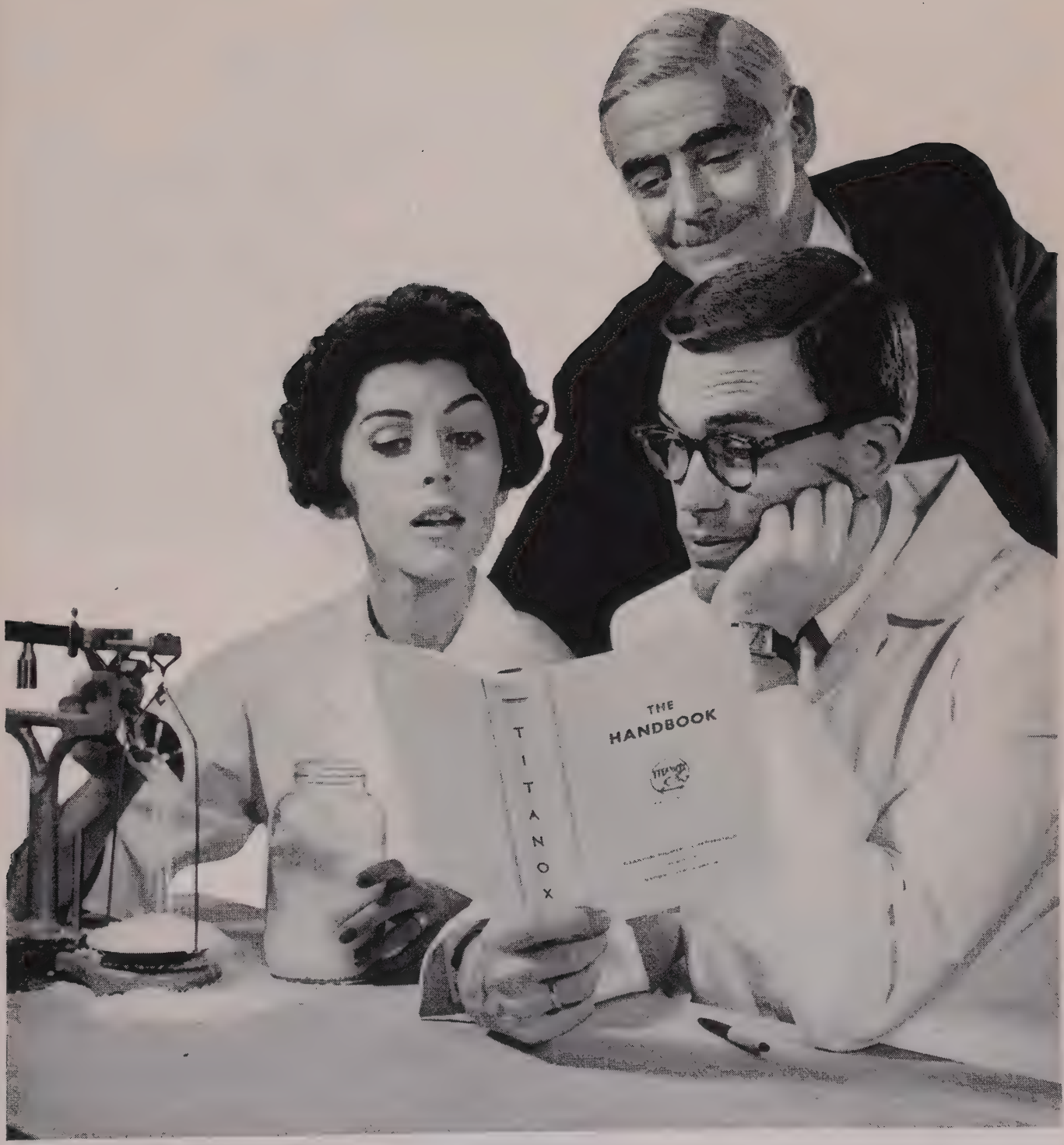

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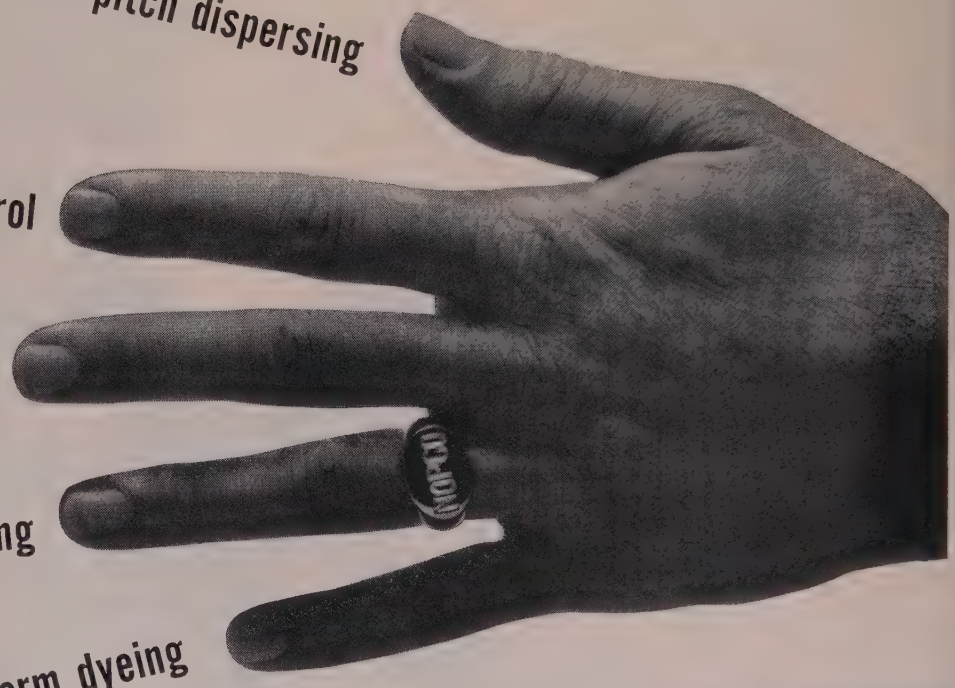

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Oldest integrated paper mill in the country: Tileston & Hollingsworth Co., Hyde Park, Mass.

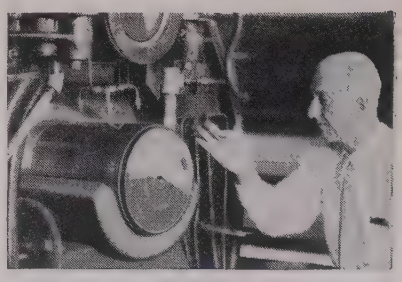
Lubrication engineer switches 230-year-old mill to Cities Service Lubricants

William D'Entremont, Lubrication Engineer for the Boston Office of Cities Service, spent three days at the Tileston & Hollingsworth paper mill making an extensive survey of their operations. He checked over dozens of machines with hundreds of lubrication points. His report convinced management to switch to Cities Service lubricants. Mr. D'Entremont's recommendations reduced the number of lubricants used by the company by one third, and at the same time increased efficiency of operations.

Typical of the Cities Service lubricants now used by Tileston & Hollingsworth are several types of Trojan grease, each fulfilling a specific and rigorous requirement. The unique properties of Trojan greases are the result of scientific use of laboratory-tested fortifying chemicals. Mineral oils comprise the largest percentage of the ingredients in Trojan greases. Only such oils are employed that are known to give the best results required of a given type—a knowledge gleaned from years of research and experience in the manufacture of high grade greases for a host of critical customers.

To learn how Cities Service lubricants can help you in your business, call the Cities Service Lubrication Engineer in your area. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

The original charter establishing this company was issued in 1728 by the Provincial Government in Mass. In its first year the charter called for the company to make *"Two hundred Rheams of good Merchantable Brown Paper and Printing Paper"* plus *"Fifty Rheams of Writing Paper of equal goodness with the Paper commonly stampt with the London Armes."* Today the mill produces that much paper in an hour.



William D'Entremont checks paper mill's machinery. His recommendations reduced number of lubricants used by company by one third.

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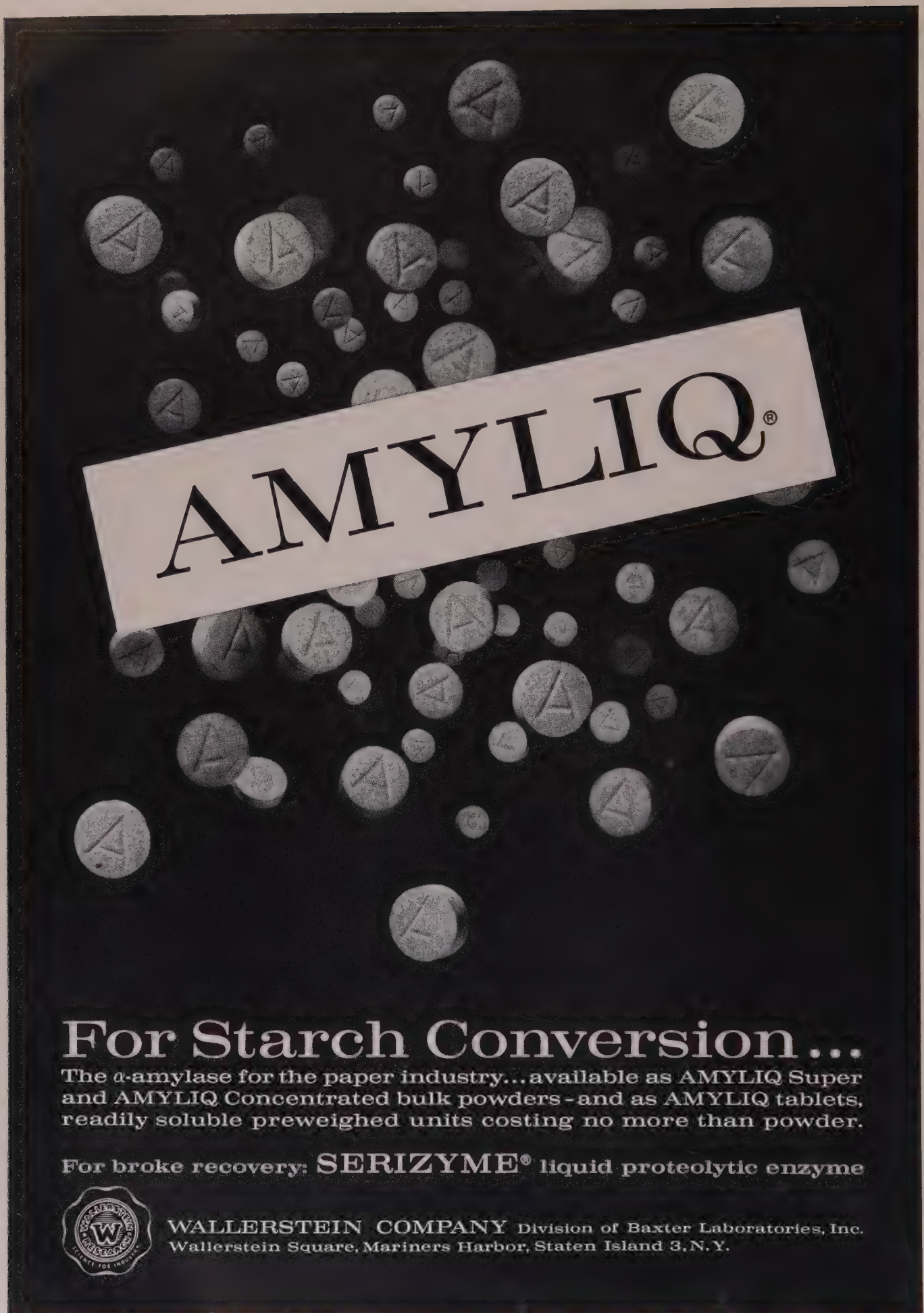

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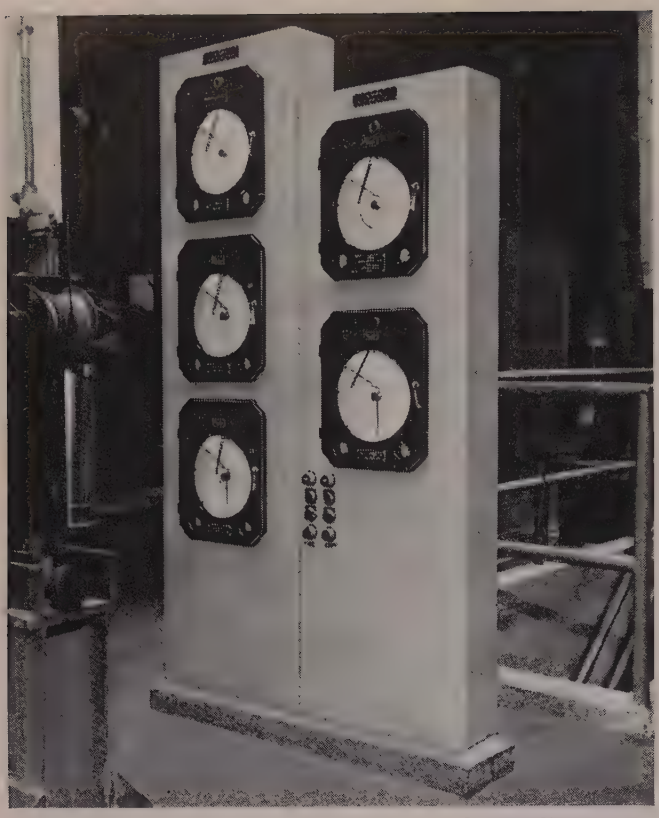
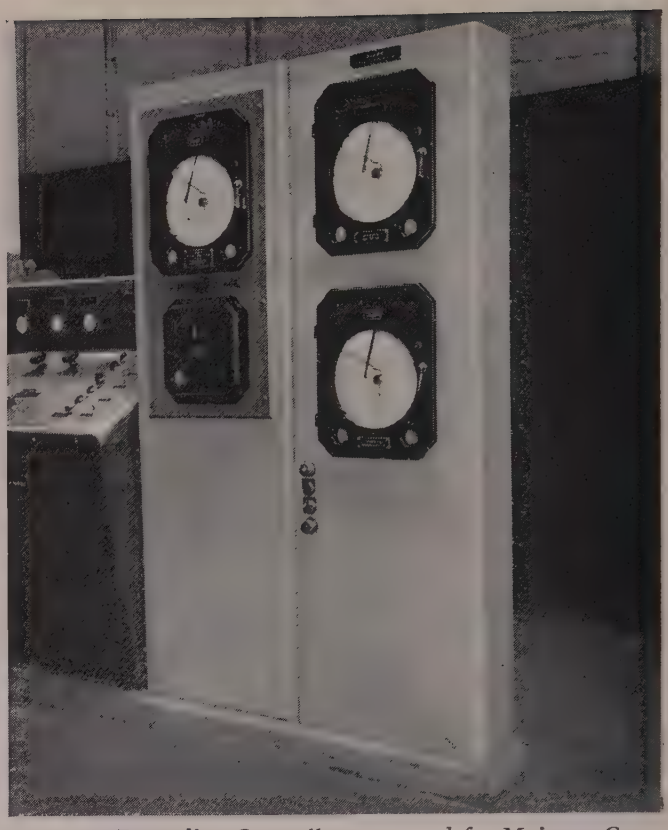


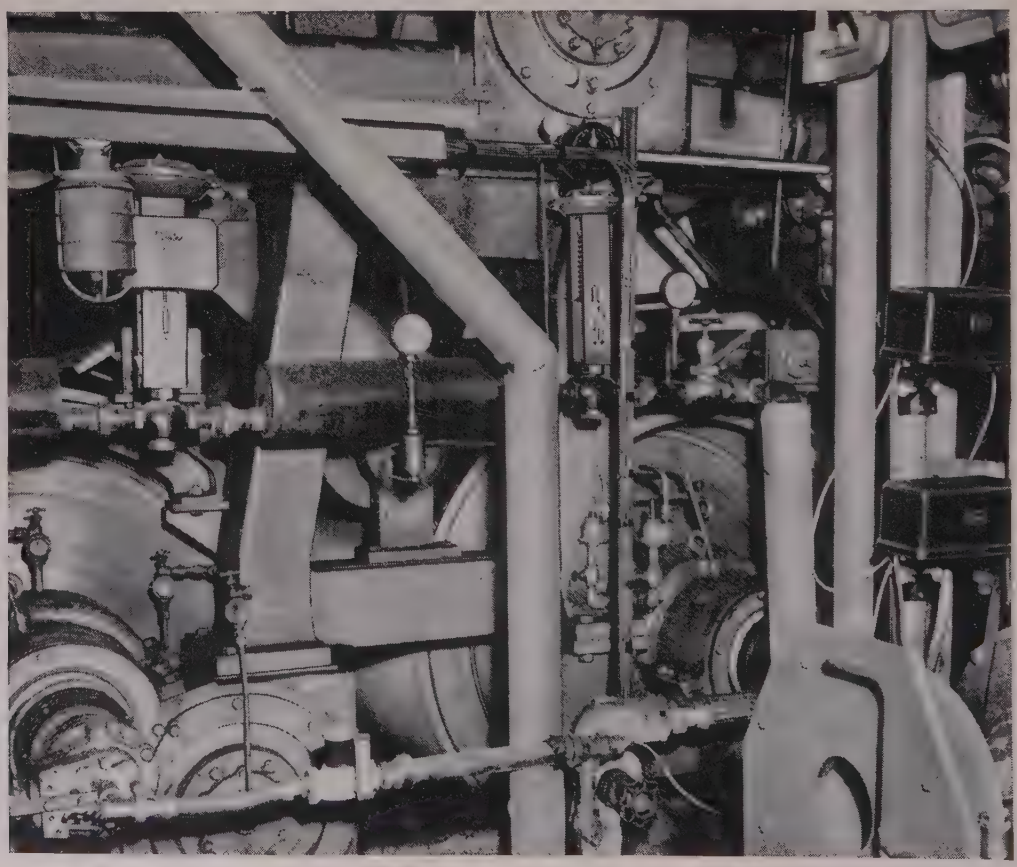
Taylor FULSCOPE Controllers, regulating and recording Steam Pressure and Differential on the Wet End; Differential Main Section; Graduated Temperature and Felt Dryers.

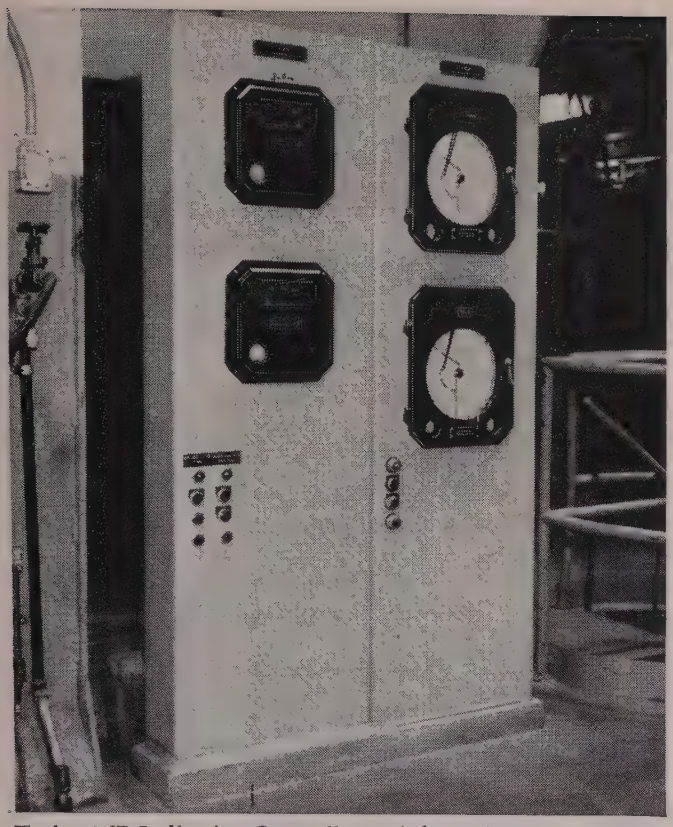


FULSCOPE Recording Controllers are used for Moisture Control; Differential Main Section and Differential Condensing Section. The Indicating model maintains Constant Pressure.

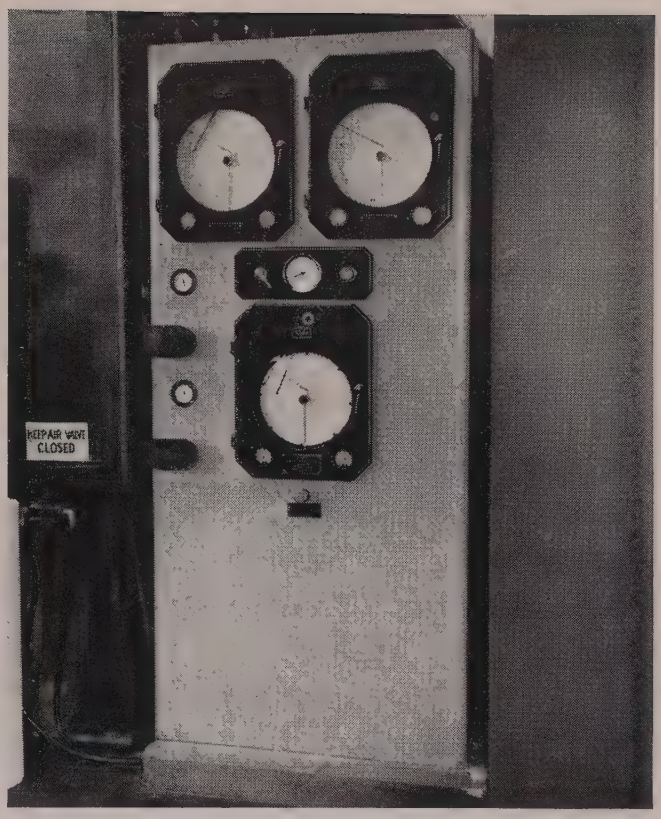
ANOTHER STAMM DRYER DRAINAGE

The heart of the Stamm System on No. 4 Machine at Chillicothe Paper, illustrating the compactness of the installation and its accessibility. In the picture are Temperature Transmitters, MOTOSTEEL* Valve, a PRECISOR* Valve Positioner and 10RF Pressure Controller for steam lines.





Taylor 86R Indicating Controllers at left regulate Temperature on Dryers Nos. 30 and 31. FULSCOPE Recording Controllers at right control the Differential Top and Bottom Dryers on the Size Section.



Dry End Panel, showing FULSCOPE Recording Controllers applied to Top and Bottom Dryers, and Moisture Control. Instrument in center is the Automatic-Manual unit. At bottom is Zero adjustment.

SYSTEM WITH TAYLOR CONTROL . . .

at Chillicothe Paper Co., Chillicothe, Ohio

This system includes:

- Graduated temperature control of the wet-end dryers.
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This Taylor controlled Stamm System is designed to give Chillicothe Paper less shrinkage, cockle, curl and better quality control. The entire system is simple to operate and requires minimum maintenance.

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Stamm Drying Controls, Inc. is well known for its engineering skill. Taylor is known throughout industry for accurate, reliable instrumentation. The combination is unbeatable.

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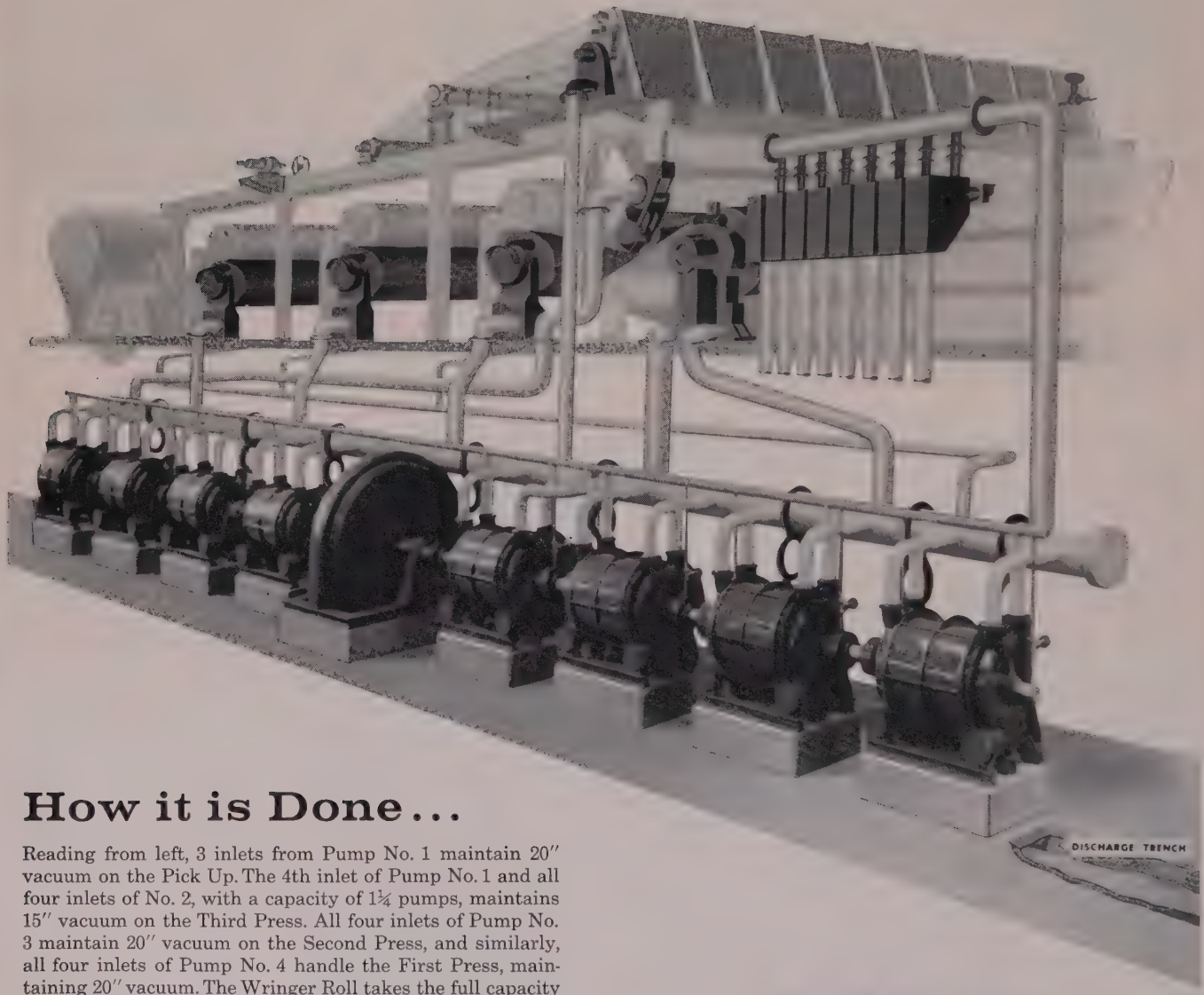

How it is Done...

Reading from left, 3 inlets from Pump No. 1 maintain 20″ vacuum on the Pick Up. The 4th inlet of Pump No. 1 and all four inlets of No. 2, with a capacity of 1¼ pumps, maintains 15″ vacuum on the Third Press. All four inlets of Pump No. 3 maintain 20″ vacuum on the Second Press, and similarly, all four inlets of Pump No. 4 handle the First Press, maintaining 20″ vacuum. The Wringer Roll takes the full capacity of Pump No. 5, requiring 10″ vacuum. The High Vacuum Couch Box takes a pump and a half, 4 inlets of Pump No. 6, and two inlets of Pump No. 7, maintaining 20″ vacuum. The remaining two inlets of Pump No. 7 maintain 10″ vacuum on the Low Vacuum Couch Box. Only one inlet of Pump No. 8 is required to handle the Felt Conditioners at 10″ and the remaining three inlets of Pump No. 8 handily maintain 10″ vacuum on the Wire Boxes.

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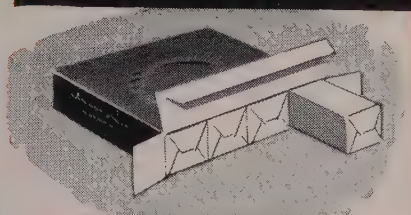

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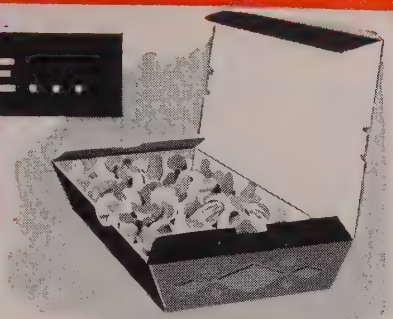

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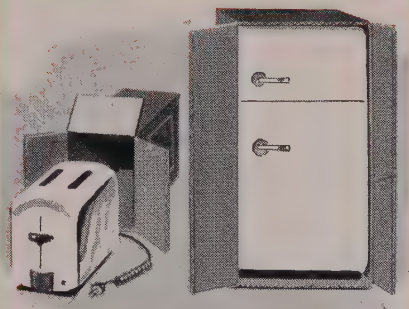

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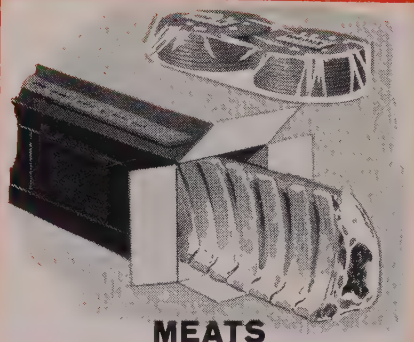
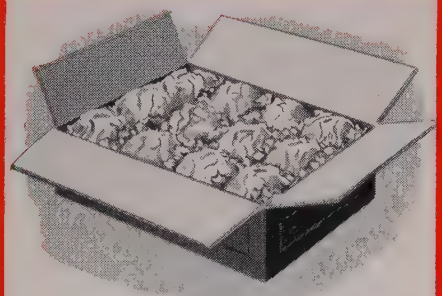


MEATS



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If grease, moisture or fine finishes present packaging problems for your product, here's how you can pack and ship them safely *without recourse to costly carton liners:*

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Write for literature, free samples. Free samples and technical data are now ready for your evaluation. Just write us at the address below. Or ask your local Semet-Solvay representative for a demonstration in your own plant. He can show you, right on your own equipment, how A-C Polyethylene can improve your cartons, save you money at the same time! *Contact us for the names of processors in your area who make up blends of A-C Polyethylene and wax.*

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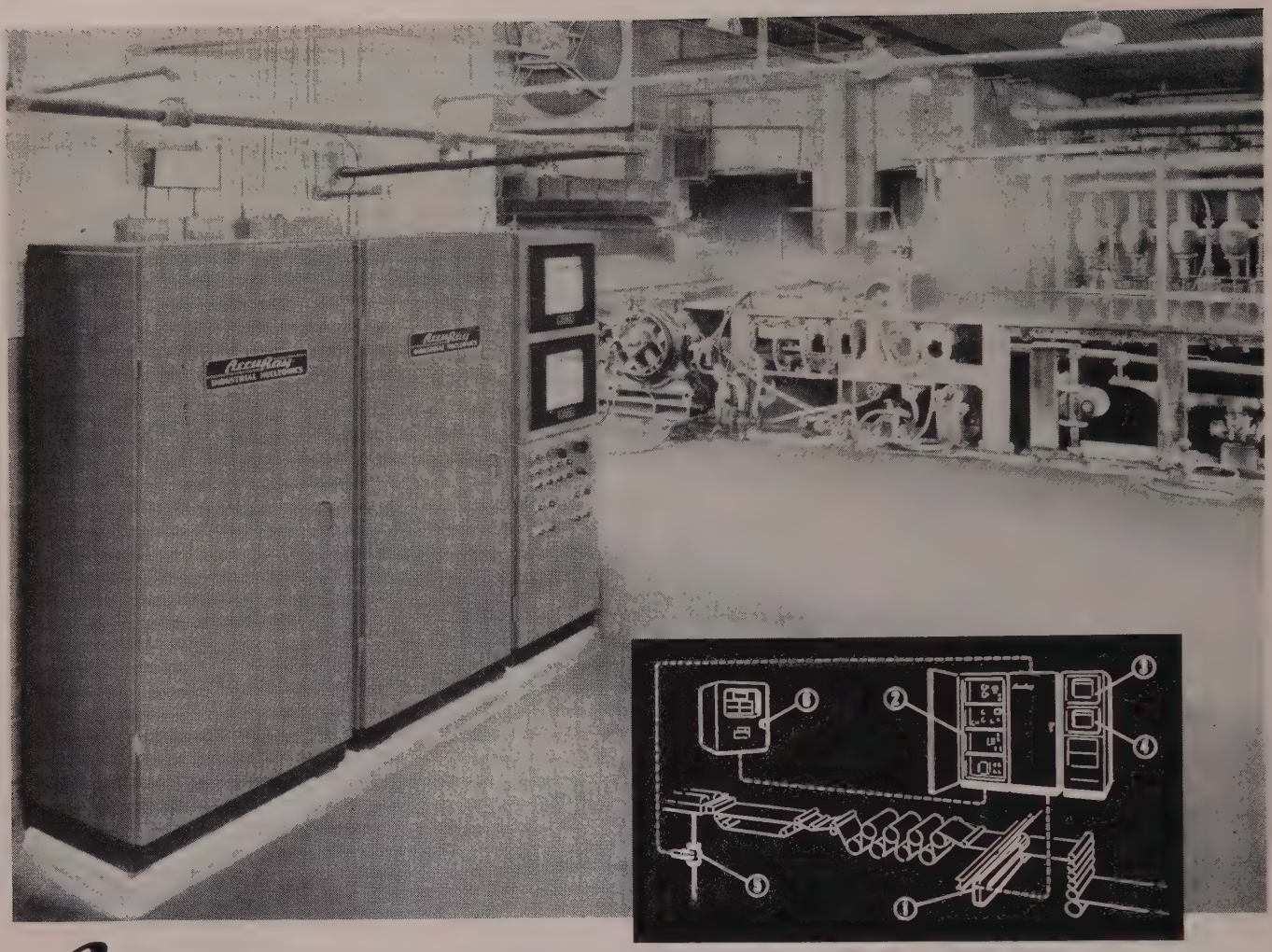


AccuRay basis weight control system *assures quality* at Howard Paper Mills, Inc.

At Howard Paper Mills, Inc., the constant quest for methods to improve quality and increase production has continued for decades. The most recent "break-thru" in this never-ending search has been the equipping of all 5 Fourdriniers throughout the company with AccuRay Data and Control Systems. These advanced basis weight systems *assure* optimum quality and peak saleable production.

As shown in the diagram above, The AccuRay Measuring Unit (1) continuously scans the moving sheet, observing minute variations in basis weight. The measurement signal is sent to remoted *Main Equipment Cabinets* (2) housing industrial computers and programing equipment which prepare the basis weight signal for readout and control action. In turn, the measurement signal is sent to the *Average Recorder* (3) which visually presents either average sheet weight at the end of each scan, continuous machine direction weight (single point) or a vertical representation of sheet profile. The *Profile Recorder* (4) horizontally records weight variations across the sheet. The *Motorized Stock Valve* (5) automatically controls stock feed as determined by basis weight variations and the *Production Analyzer* (6) numerically and visually classifies production into Premium, Within Specifications or Reject Footage.

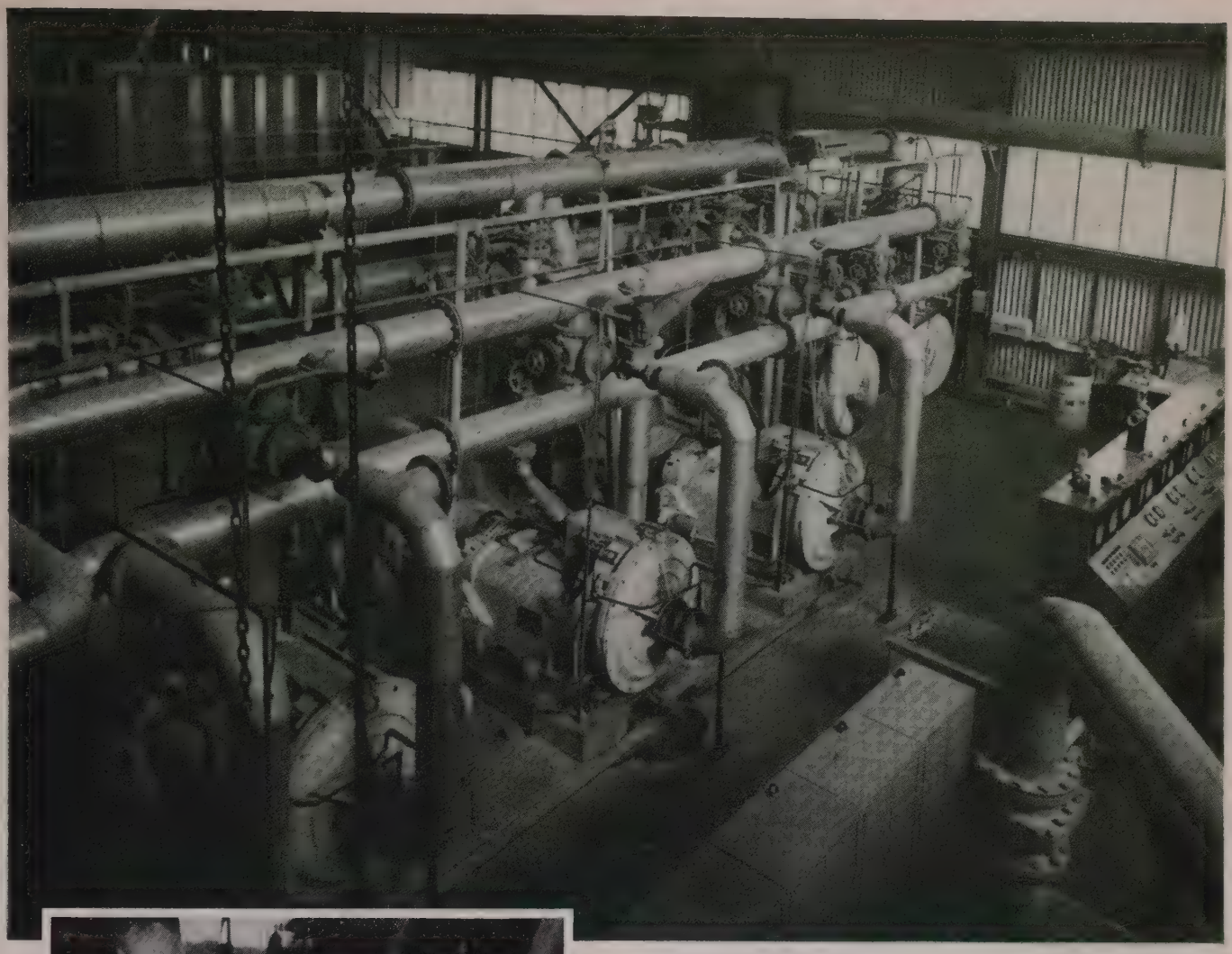
The use of AccuRay Continuous Basis Weight Measurement and Control Systems is just one more reason why Howard Paper Mills, Inc., can claim that Howard Papers are truly "The Nation's Business Papers".

The **WORLD'S LARGEST** *Manufacturer of Nucleonic Industrial Process Control Systems*

Industrial Nucleonics CORPORATION

650 ACKERMAN ROAD
COLUMBUS 14, OHIO

23 YEAR DISC LIFE INDICATED



After two years of tough work Jones Double-D Super-Stainless discs show only .065" wear — evenly distributed and with parallelism perfectly retained.

for Jones Double-D's on the Seminole Chief

Sept. 7, 1957 was the day St. Regis began to produce their fine quality Seminole Chief Board in Jacksonville — with the help of ten Jones Double-D's for both primary and secondary refining. Regular six month checks of the Jones Super Stainless discs in each Double-D show a maximum wear of only .0027" per month. Applied against the available disc wear of .750", this actually indicates a disc life of more than 23 years!

This fine record has been made, too, under heavy power requirements — normally more than 600 HP and sometimes running as high as 1000 HP on each primary refiner for periods of several weeks!

Have a tough refining problem? Better look into the Jones Double-D. Write to E. D. Jones Corporation, Pittsfield, Mass., for bulletin EDJ1083.

E. D. JONES CORP. Member BELOIT GROUP PITTSFIELD, MASS.

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Bigger Sales...

- No decrease in tensile strength
- Increased cross-directional tensile strength
- No effect on colors
- Rewetting properties are unaffected

Better Production...

- Machine speeds maintained or increased
- Smoother running machines — less down time
- Will not yellow or develop odors on ageing
- Will not foam or froth in use

CELLOLUBE® Q-2

Quaternary Ammonium Paper Softener

Cellolube Q-2 softens napkins, tissue and towel stocks *without adverse effect on physical properties* — puts added "soft sell" in the finished product . . . without creating processing problems. And Cellolube Q-2 gives you wider latitude in pulp selection too! Sheets leave the doctor blade more uniformly, with a finer crepe. And machines actually run more smoothly with less down time. For a revelation in superior paper softening test Cellolube Q-2 now!

Economical Cellolube Q-2 treats tissue stock for as little as $1.33 per ton, and toweling for $3.30 per ton. Increased processing speeds may actually lower your over-all costs! Tanatex is prepared to demonstrate Cellolube Q-2 in your mill on a full scale trial. For details write, wire, phone:

TANATEX CHEMICAL CORPORATION

Belleville Turnpike, Kearny, New Jersey
WYman 8-0732

CHEMICALS
FOR DIFFICULT PROCESSING

New Felt Facts

FILLING-UP PROBLEMS?

Try Albany's proven 1-2-3

Felt Washing Program!

Nearly everyone has the problem of keeping paper machine felts clean and open throughout their life.

Albany Felt has done something about this by establishing a separate department whose FIRST and ONLY function is to be of service to you in this vital area.

Many paper mills already have taken advantage of this new service. All have shown outstanding improvement with higher machine speeds, better drainage and prolonged felt life.

AF

ALBANY FELT COMPANY

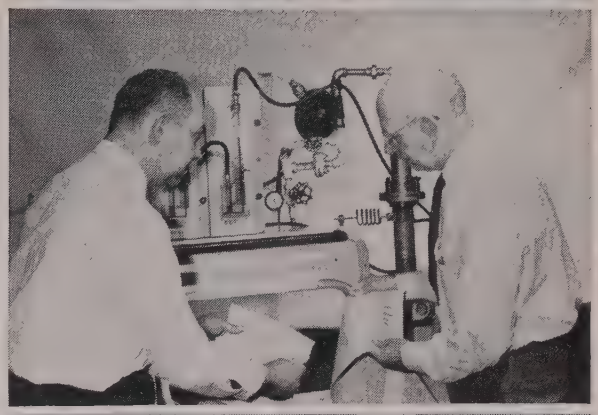
ALBANY, N. Y.

The World's Largest Manufacturer of Paper Machine Felts

. . . . Here's How Albany's Felt Washing Program works!

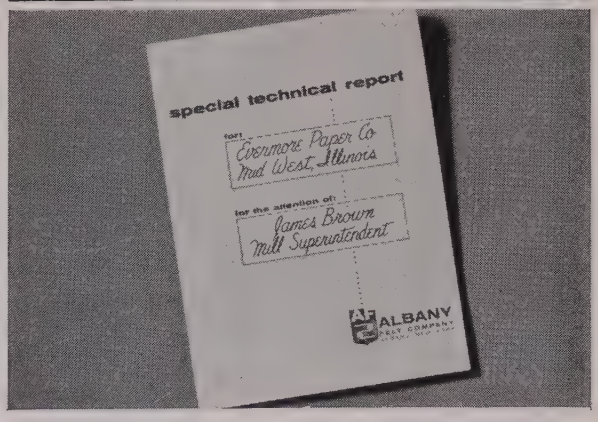
1. On the spot analysis

Because there is no universal cleaning solution or felt cleaning method, our felt washing program engineer visits your mill to work with you on your individual problem.



2. Laboratory testing

Next we use the latest scientific equipment and chemicals to test portions of your used felts to discover the best cleaning compounds and washing equipment to fit your needs.



3. Written report

Specially trained engineers then submit a written report to you covering every phase of their recommendations of a felt washing program tailored to your operation.

If you feel your present felt cleaning procedures may be improved or if you wish information on the adaption of proven methods to your particular machines—

TALK IT OVER WITH YOUR ALBANY FELT SALES ENGINEER

ClO_2

GASPESIA NOW HAS CHLORINE DIOXIDE PULP!

Don't commit yourself on future orders for sulphite pulp until you've tried the *new* Gaspesia Chlorine Dioxide pulp.

This high-quality new ClO_2 pulp is now being produced in a bleach plant only six years in operation. Space was left for this Chlorine Dioxide operation in the original plant plans. Now, Gaspesia is the only North American sulphite pulp made from northeastern woods bleached in a completely modern bleach plant, utilizing chlorine dioxide.

Gaspesia pulps have long been known for their excellent cleanliness, strength and good forming qualities. Now chlorine dioxide makes possible a brightness of 91 G.E.

Orders for trial cars are now being accepted. We suggest you order your initial shipment today to assure a steady supply in the years ahead.

GASPESIA SULPHITE COMPANY LTD.
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Illustration courtesy of The Curtis Publishing Company

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The subtle tones and detail of this illustration, printed by four-color offset lithography, are reproduced in true value because of the paper on which it is printed . . . paper which uses RHOPLEX all-acrylic emulsion as the binder in its coating.

Sharpness of halftone dot definition, freedom from picking, and exceptional varnish holdout are features which appeal to the printer who demands quality of reproduction with high speed presswork.

Papermakers like the ease with which RHOPLEX can be used for on or off-machine coating by trailing blade, air knife or roller coater. They can achieve high coatings weights and still enjoy high speed operation because coatings as high as 65 percent solids still have good handling viscosity when RHOPLEX is the binder.

For full information about RHOPLEX B-15 and RHOPLEX B-60A write for your copy of "RHOPLEX Acrylic Emulsions in Paper Coatings".

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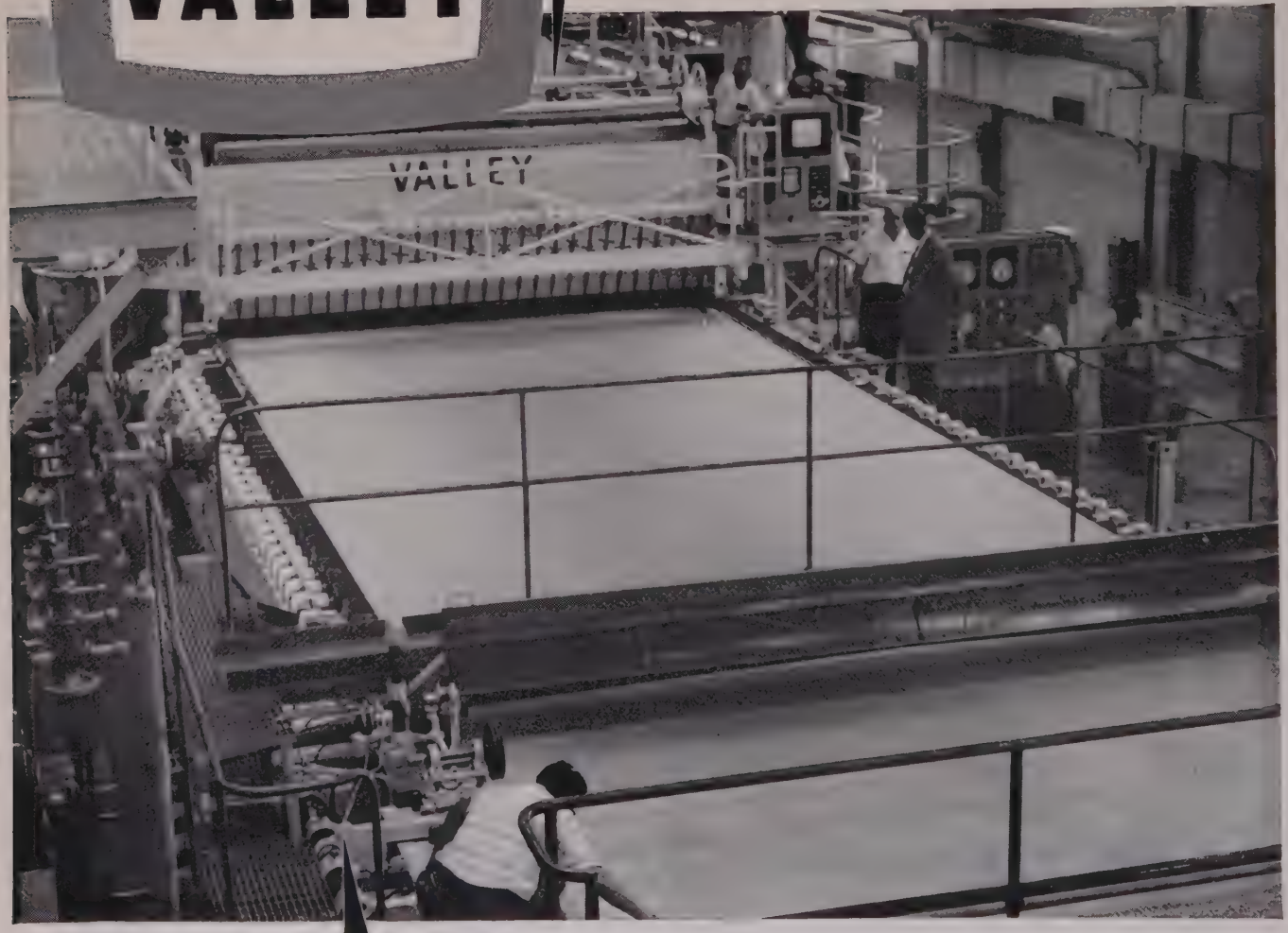

Consult... **VALLEY IRON WORKS CORPORATION**

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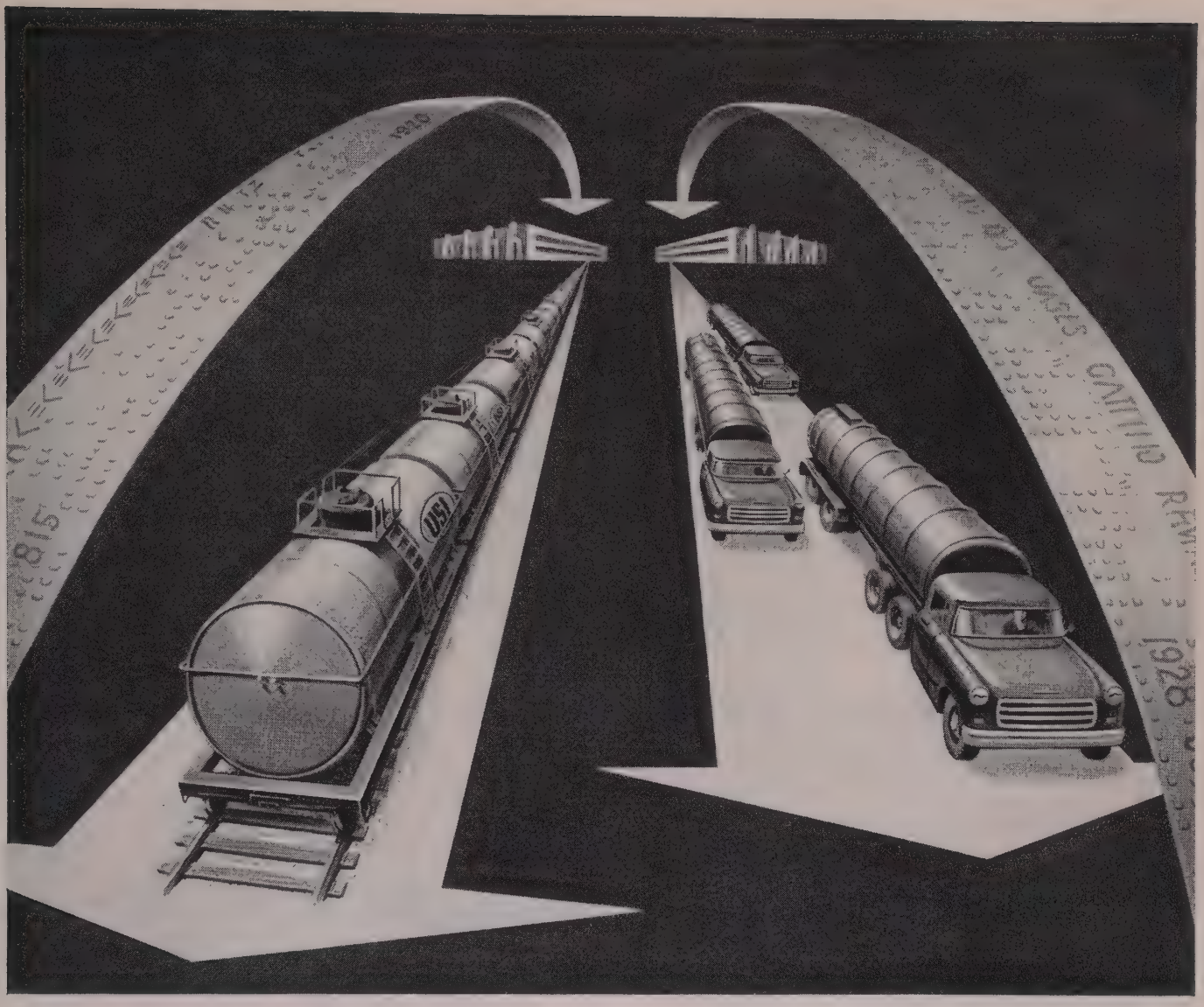

AUTOMATION SPEEDS U.S.I. CHLORINE AND CAUSTIC SODA

. . . from Huntsville, Alabama

To U.S.I., customers' orders are high priority communications. That's why our offices and plants all over the country are linked in a 7,000-mile private wire network of teletypes and data processing equipment.

As one of U.S.I.'s customers for chlorine or caustic soda, here is the way this automated order handling system would insure quick delivery of *your* shipment. When your order is placed with the U.S.I. sales office in your area, it is transmitted by coded tape direct to Huntsville, Ala. Here automatic machines use the tape to produce shipping papers, invoice and such records as are needed for internal use. The system cuts as much as four days from the time that might be required to process your order by ordinary methods.

Ample capacity at U.S.I.'s two Huntsville plants is further assurance of expedited service.

Liquid chlorine is shipped from Huntsville in tank cars, commercial grade 50% liquid caustic soda in tank cars, tank trucks and barges. Other U.S.I. plants supply ammonia, polyethylene and sodium peroxide. Make U.S.I. *your* supplier of these paper chemicals. Our products and ability to serve you are discussed in the booklet "National Distillers and Chemical Corporation Expands in the Chemical Industry". We'll be happy to send you a copy.

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99 Park Avenue, New York 16, N. Y.
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- ☐ Have a salesman call for an appointment to discuss chlorine or caustic soda
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Address_____

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U.S.I INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
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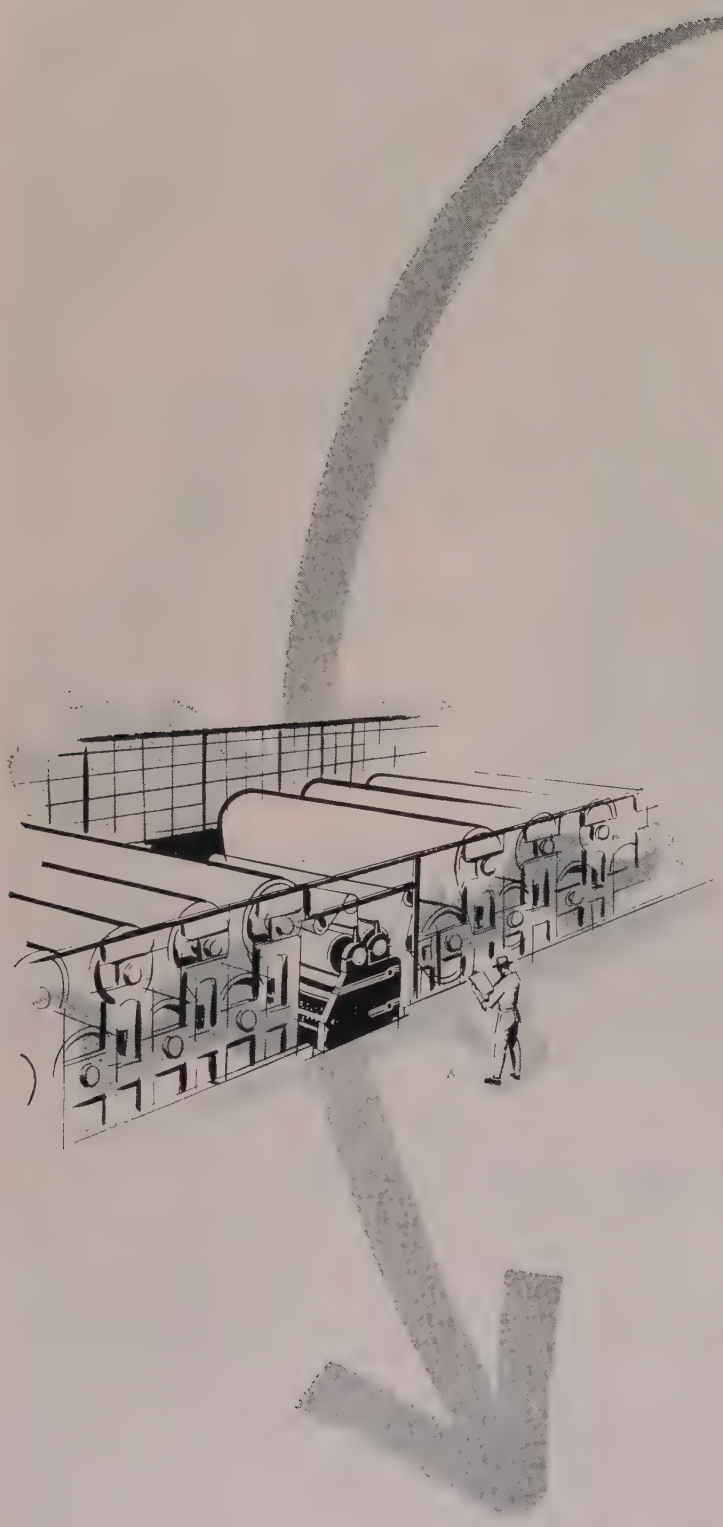

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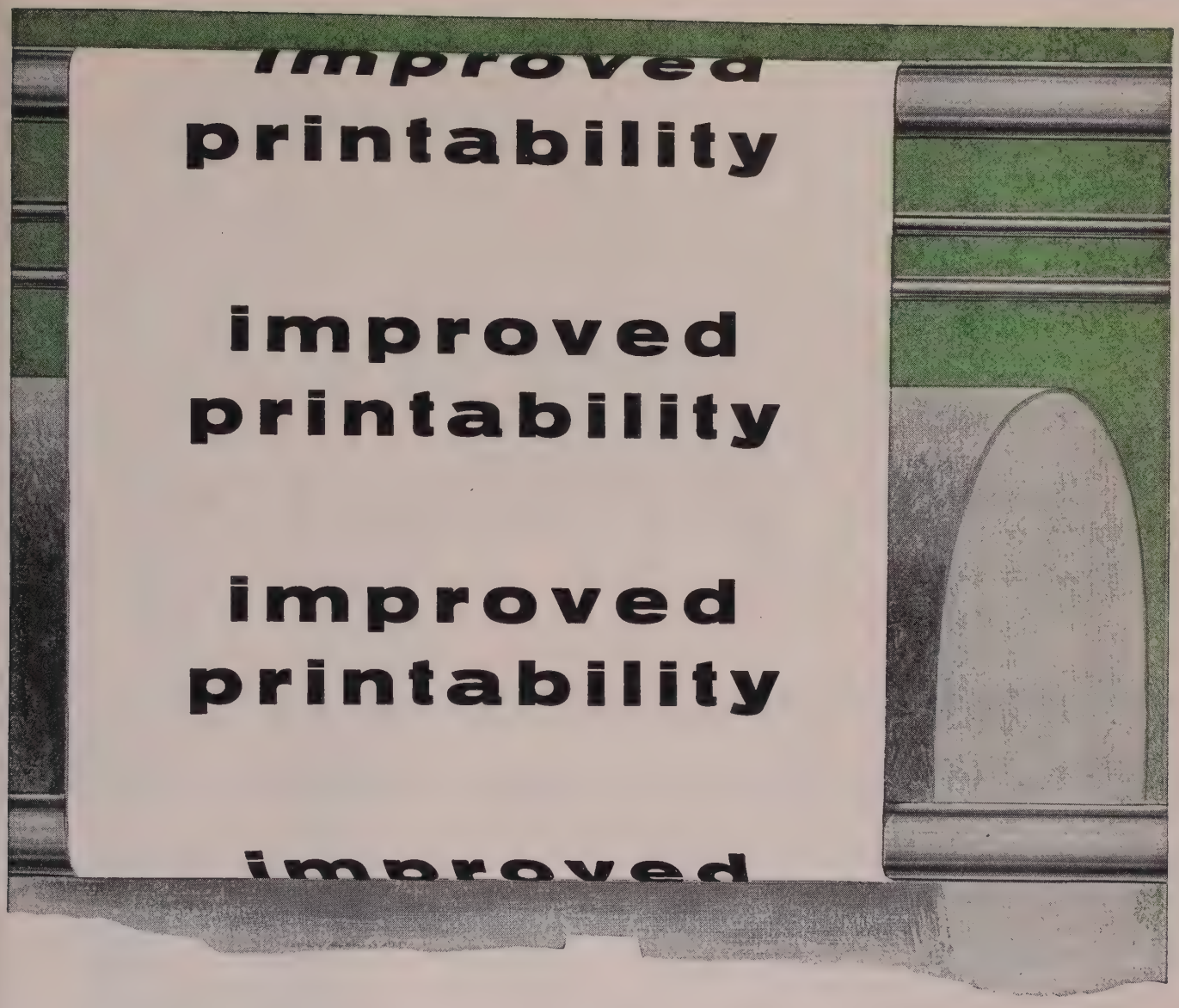

with Gelva C-3 and C-5 copolymer resins

When used as a surface size, GELVA C-3 and C-5 polyvinyl acetate copolymer resins impart a smooth finish to paper. Ink receptivity is improved. Contrast is sharply defined. Furthermore, when deposited from ammoniacal solution, the resin imparts to the sized sheet a more water resistant film. Improvements in wet and dry tensile and Mullen are also obtainable. The resins are alkali soluble. Broke recovery is quick and easy.

Write for full technical information on GELVA C-3 and C-5. Shawinigan Resins Corporation, Department 6203, Springfield 1, Massachusetts.

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Form—Fine beads (0.2—1.0 mm. diameter)
Transparency—Excellent
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	Softening Point	Maximum Flowable Solution
C-5V-10	123°C	20%
C-3V-10	123°C	35%
C-5V-16	134°C	20%
C-3V-20	155°C	25%
C-3V-30	180°C	20%

Softening Point: Ball and Ring Method
Solution: Ammoniacal

GELVA® *polyvinyl acetate resins by* **SHAWINIGAN RESINS**

What's the best way to bleach cold caustic pulp...

TOWER or REFINER?

Let Du Pont—the producer of both hydrogen peroxide and sodium peroxide—help you make this key decision

You may save thousands of dollars in capital investment and chemical cost if you make the right choice between bleaching in a refiner or in a tower.

Du Pont has a thorough working knowledge of both systems and, as the producer of both sodium peroxide and hydrogen peroxide, can tell you which peroxide or combination of peroxides is best for you.

Du Pont technical men will work with you and the equipment manufacturer of your choice to obtain the best peroxide bleaching process for your cold caustic pulp. They may recommend refiner bleaching requiring a small investment for peroxide solution make-up equipment with possible brightness increases of up to 20 points . . . or if your operation calls for it, they may recommend tower bleaching. When combined with Du Pont's acidification process and a peroxide treatment, tower bleaching can increase brightness up to 35 points.

Add Du Pont's experience to your own, and you're sure to make the right choice. Call your Du Pont representative; he will be glad to discuss any bleaching problem you may have.

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DU PONT PEROXIDES

SOLOZONE® sodium peroxide • **ALBONE®** hydrogen peroxide
for better bleaching of groundwood—sulfite—kraft—cold soda

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ELECTROCHEMICALS DEPARTMENT, E. I. DU PONT DE NEMOURS & CO. (INC.), WILMINGTON 98, DELAWARE

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Atlantic builds waxes which add trouble-free sales appeal to any product. Those recommended for paper goods assure you of a hard, glossy, scuff-resistant surface with lasting protection against blocking.

Blocking (or sticking together) occurs most often when a wax loses its hardness. Tough, hard, high-melting Atlantic 1115 Wax gives your products good blocking resistance in hot summer temperatures. Atlantic 1115 Wax is also highly resistant to the deteriorating effect of vegetable oils, so that containers stay firm and leak-proof for long periods of time.

Atlantic makes a superior wax for every use. Selecting the right wax is quick and easy when you call in your Atlantic man. He's an experienced consultant . . . knows which waxes to recommend for hardness, flexibility or a combination of these and other characteristics.

He'll arrange deliveries to suit your needs . . . in cartons or pallets, in bulk haulers or in tank cars. For full information write your nearest Atlantic office. The Atlantic Refining Company, 260 South Broad Street, Philadelphia 1, Pa.

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THERE'S AN ATLANTIC WAX FOR EVERY USE

photo courtesy of Thilmany Pulp & Paper Co., Kaukauna, Wisconsin

ACRI-FLO 151 helps wrap out the weather

For years paper manufacturers have searched for an economical, non-staining protective kraft that would wrap out the weather. Now that search has ended! With Acri-flo 151 it is possible to produce such a wrap . . . a high-impact, duplex kraft from less costly sheets. This is only one of the many ways Acri-flo has helped the paper industry produce better products at lower cost. A letter from you today will bring you proof of how Acri-flo can help improve your paper products!

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Chemicals for the rubber, paint, paper, textile, plastics and other industries: **GENTRO SBR** *rubber* **GENTRO-JET** *black masterbatch* • **GEN-FLO** *styrene-butadiene latices* • **GEN-TAC** *vinyl pyridine latex* **GENTHANE** *polyurethane elastomer* • **ACRI-FLO** *styrene-acrylic latices* • **VYGEN PVC** *resins and compounds* • **KURE-BLEND** TMTD *masterbatch* • **KO-BLEND** *insoluble sulfur masterbatch*

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Bauerite

PAYS OFF

Four mills* of the many using the Bauerite® process to make groundwood type pulp from chips are **doubling** their production. Wood economics often force mill owners to look for a substitute for their dwindling supply of softwoods.

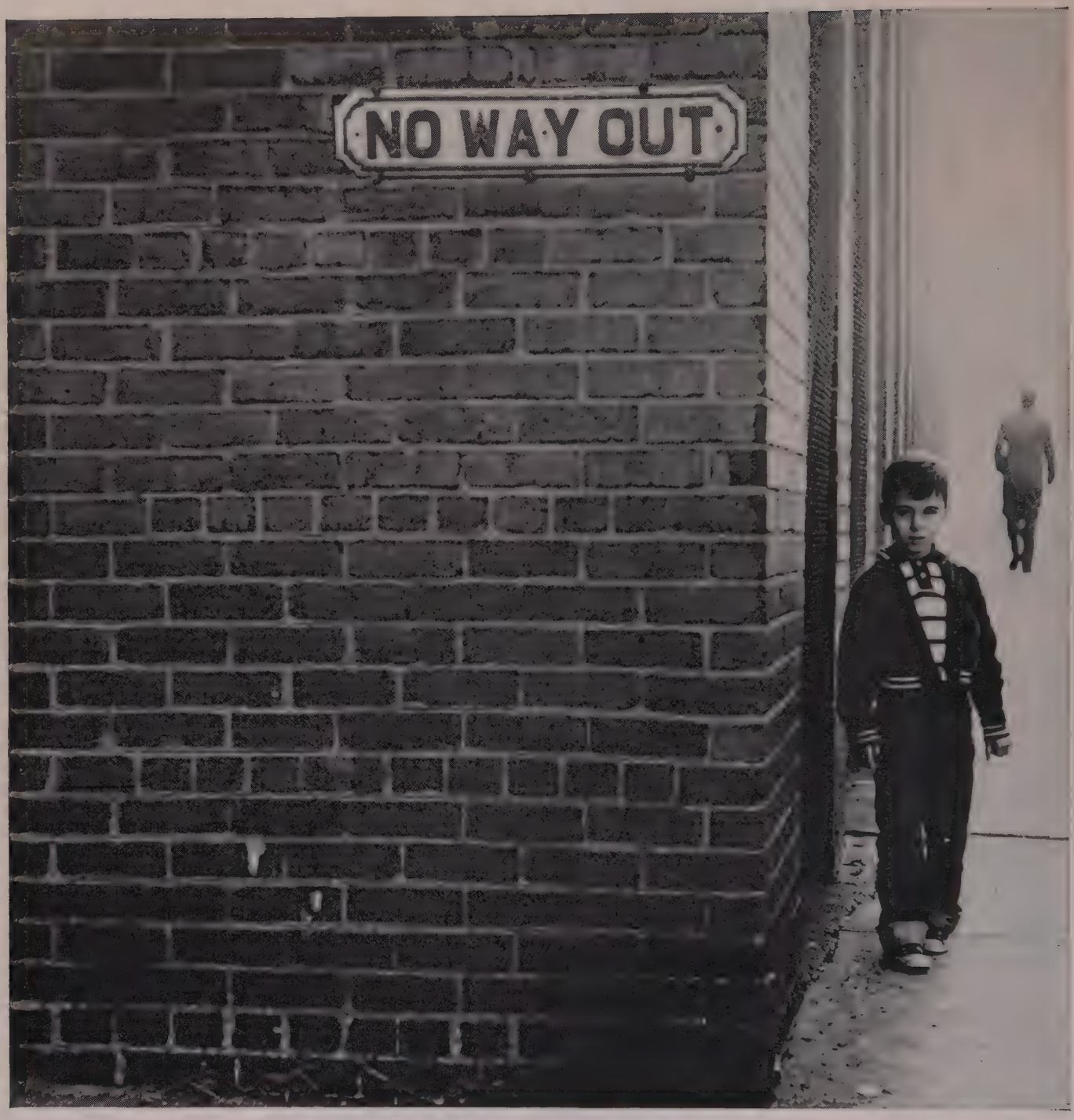
Production advantages, new economies and greater profits are available with the Bauerite process. For instance, many have gained a constancy of quality superior to that possible with conventional groundwood. Slabs, edgings, certain sawdusts and chips of irregular size—in various blends and often from species of wood previously not suitable—are being used from local sources. These are some of the reasons why mills find this process profitable. Write, or ask your Bauer representative for complete information.

**Gould Paper Co., Lyons Falls, N. Y.; Daishowa Paper Manufacturing Co.; Jujo Paper Manufacturing Co. Ltd.; Tokohu Pulp Co. Ltd., Japan.*

The Bauer Bros. Co.

1715 Sheridan Ave., Springfield, Ohio

This Bauer double revolving disc refiner is bound for Gould Paper Co., Lyons Falls, N. Y., where production of Bauerite groundwood pulp from chips will soon be doubled.



...OR IS THERE?

Leukemia now gives its young victims only months of life. But there *is* hope for those with this form of cancer. That hope is research.

Research has already extended the lives of many leukemia patients by months and even years. Research alone can find a way to stop this cancer of the blood-forming tissues once it has mysteriously begun. And every day that a leukemia patient lives allows science one more day to find a cure —or even a new way to extend his life a little longer.

Every year leukemia kills 2,000 children and 10,000 adults, and the incidence is rising. Every year the American Cancer Society allocates more and more money to research specifically related to leukemia. Last year, it allotted nearly $1,000,000 to such research, out of a total research expenditure of about $12,000,000. Much more money is needed this year. The more you contribute, the faster research on leukemia and other forms of cancer will progress. Guard your family! Fight cancer with a checkup and a check! Send your contribution to "Cancer," in care of your local post office.

AMERICAN CANCER SOCIETY

METASOL

SLIME CONTROL ENGINEERING

Scientific slime control methods now available

METASOL *microbiologist prepares petri dish test to determine micro-organism count of white water.*

New METASOL Krylate Spray keeps surfaces slime-free for extended periods

A new METASOL slimicide product, METASOL Krylate Spray, is another weapon in furthering the effectiveness of a slime control program. When applied to wood, ceramic, concrete and steel surfaces, METASOL Krylate forms a slime-resistant, water-resistant film which keeps these surfaces slime-free for months.

METASOL Krylate is packed in pressurized aerosol containers and sprayed on the desired surface by means of a spray nozzle. Its principal use is on suction boxes, doctor blades and similar inaccessible areas which cannot be cleaned regularly.

Used in conjunction with METASOL Slimicide, METASOL Krylate provides an effective and lethal one-two punch to slime-producing organisms.

A word about METASOL Slimicides

METASOL Slimicides were developed after 7 years of intensive testing and evaluation of almost 2,000 slimicidal products. Chemically, they have a unique di-phenylmercuric ammonium propionate structure. Their special advantages are: high, fast solubility in water; minimum deactivation; rapid initial kill and sustained killing action. They also do not allow resistant organisms to form. METASOL Slimicides will not impart color or odors to the paper. Available in either solid or liquid form, METASOL Slimicides have produced outstanding results in effective slime prevention.

Microbiological and chemical analyses show the way

Microbiological slime is a constant, persistent enemy to paper mills. In fact, many mill men are resigned to the fact that they will always have a slime condition and that the only way to achieve reasonable control is by constant trial-and-error experimentations with different slimicides. While understandable, this attitude can be costly and uneconomical when measured in terms of slimicide cost, quality variations and down time.

Importance of Scientific Analysis

The point is, effective slime control is possible if the problem is approached with scientific exactness. The source and type of infection must be properly identified. Then a formal program must be developed which details proper slimicide treatment and application, insures proper training of personnel in slime control methods and which insures systematic follow-through and inspection.

Microbiological Analysis

The initial analysis must be conducted at the mill under trained microbiologists, using specialized equipment and scientific methods. Because most mills do not have such facilities, the METASOL DIVISION maintains a field service of microbiologist teams equipped with portable laboratory equipment. The services of these teams are available to mills without cost. It is part of our established policy to provide paper mills with the finest in slime control products and techniques.

Programming Success

METASOL's slime control programming has been uniformly successful. In mills where it has been installed, machines are cleaner, periods between boil-outs have been lengthened, paper quality is higher and slimicide costs have been kept under control. For further information on this service, write or call us.

METASOL DIVISION, Metalsalts Corporation, 200 Wagaraw Rd., Hawthorne, N. J.

METASOL Slime Control Products are produced by Metalsalts Corporation, Hawthorne, N. J.

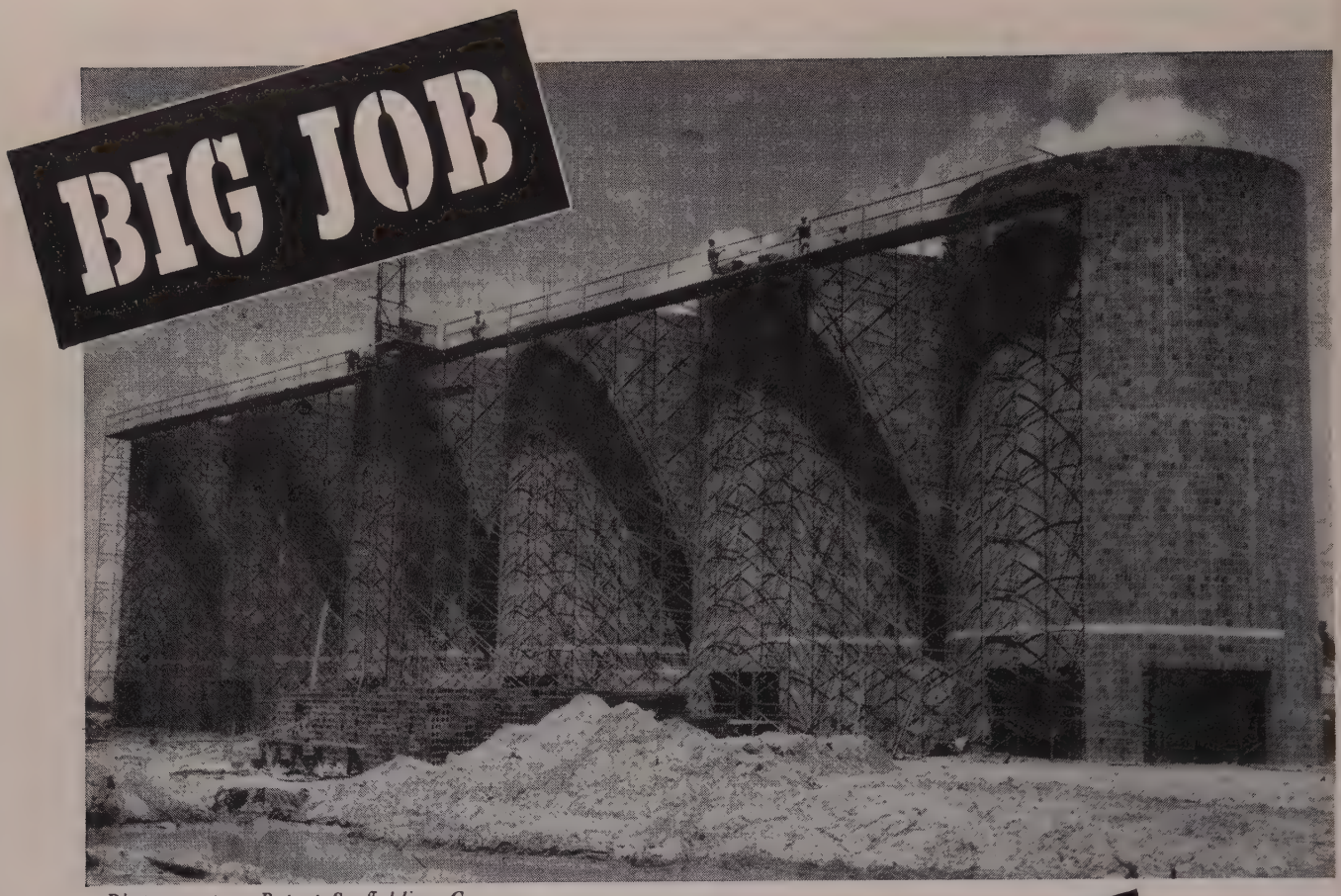


Photo courtesy Patent Scaffolding Co.

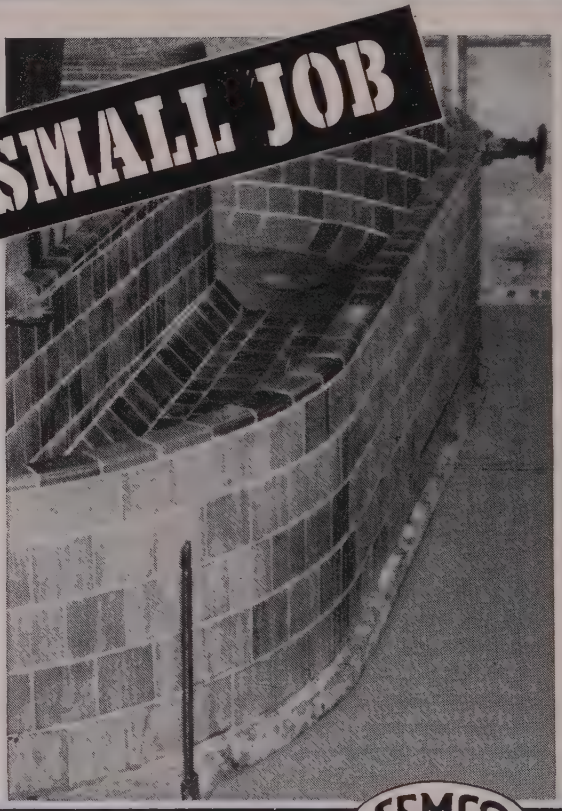
Complete Service

Design, Installation and Maintenance of

LININGS and TILE TANKS

Any job—from the very largest to the smallest—can be installed by Stebbins under a simple contract which covers everything from the original design, which is based on a full knowledge of the chemical, physical and mechanical requirements, to the finished job ready for use. Maintenance can also be included. As proved by the experience of leading mills throughout the country, you can rely completely on Stebbins service.

See Chemical Engineering Catalog or Write for Information



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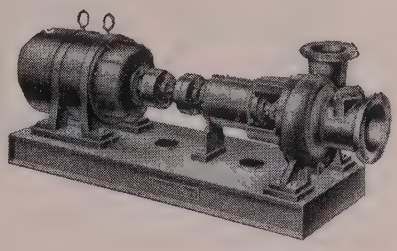
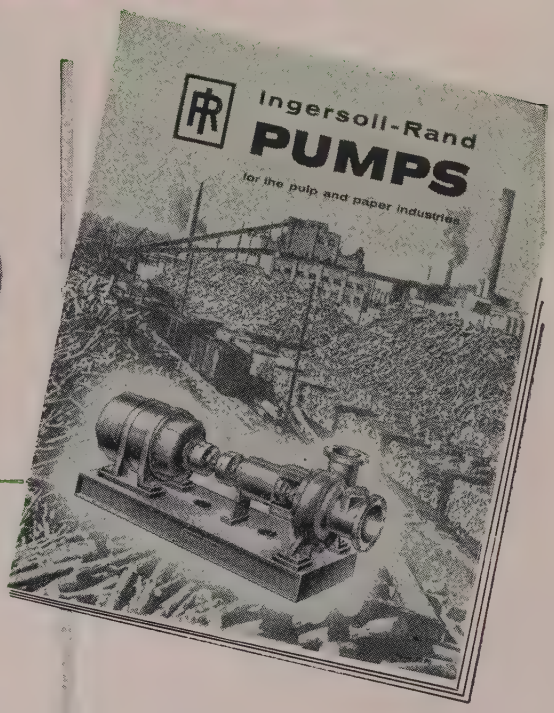
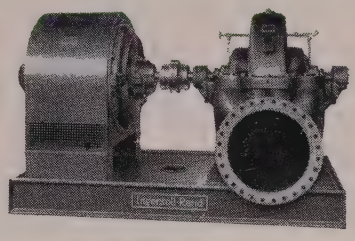
PUMPS MEAN RELIABILITY
for the pulp and paper industry

STOCK PUMPS feature the patented diverging-type impeller in classes EL, EM and EH. This unique design will handle paper stock heavily entrained with air—where other ordinary stock pumps will fail. In addition, the special impeller has handled various types of stocks from 7% to 8% consistency without the aid of a mechanical feed! Over 10% stock has been pumped with a screw-feed arrangement on the suction. For lower stock consistencies and where there is no air problem, classes CL, CM and CH pumps having a conventional impeller can be furnished. For all classes—heads: To 225 ft; capacities to 7000 gpm; sizes 4, 6, 8, 10, 12 inches.

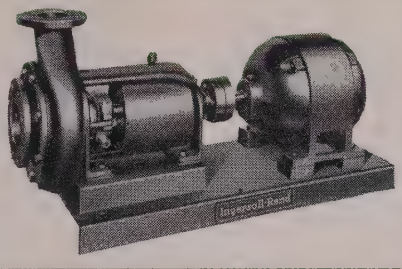




FAN PUMPS of single-stage, double-suction design are ideal for handling comparatively large volumes of liquids at low and medium heads. These pumps may be driven by any type of prime mover, and embody thoroughly modern design features that increase efficiency, insure reliability and lower maintenance costs. Capacities to 60,000 gpm.

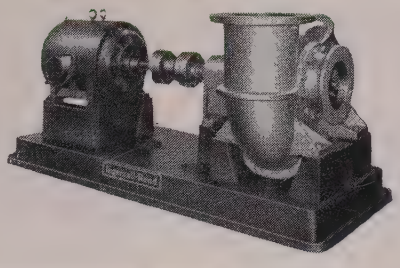


CHEMICAL PUMPS are offered in a complete line for handling hot and cold acids and alkalis. They are single-stage units of end-suction design that are ruggedly constructed to last longer on the job. For handling highly corrosive liquids, these pumps are built of IRCAMET, a high nickel-chromium-molybdenum alloy steel that is corrosion resistant. Heads to 200 ft; capacities to 4000 gpm.

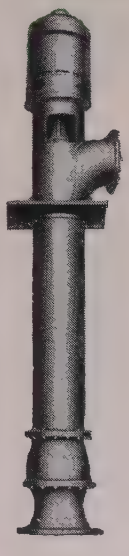


BULLETIN 7296 gives you further specifications and descriptions of all Ingersoll-Rand pumps for the pulp and paper industries. Its 24 pages are filled with cross-sections, data and installation photographs of I-R pumps at work in pulp and paper mills. For your copy of Bulletin 7296, contact your nearest I-R representative or write Ingersoll-Rand, 11 Broadway, N.Y. 4, N.Y.

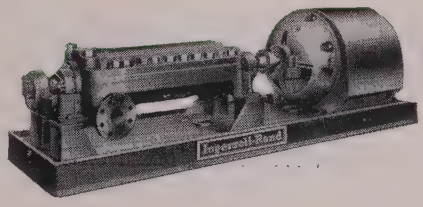
MIXED AND AXIAL FLOW PUMPS have a simplified construction that means fewer parts and less maintenance. Mixed-flow BPM propeller type is specifically designed to deliver large capacities at moderately low heads. Class APL axial-flow pumps are specially designed for handling large volumes at low heads. For both classes—heads to 40 ft; capacities to 20,000 gpm.



VERTICAL PUMPS are designed to handle liquids at heads ranging from a few feet to many hundreds of feet. Heavy-duty construction and high efficiencies are featured. Pump lengths and discharge locations can be furnished to suit the application.



BOILER-FEED AND DEBARKING PUMPS come in three types, each with symmetrical case and Unit-Type rotor design for easier maintenance and better operation. CNTA pumps are horizontally-split units available in 1-1/2, 2, 2-1/2 and 3 inch sizes. Capacities to 700 gpm; pressures to 1000 psi. HMTA pumps are horizontally-split units available in 2, 3, 4, 5 and 6 inch sizes. Capacities to 1600 gpm; pressures to 1200 psi. CHTA pumps are of "double-case" construction with vertically-split, forged steel outer casing. Available in 3 through 12 inch discharge sizes. Capacities to 7200 gpm; pressures to 6500 psi.



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this laminated board was joined with SCRIPTITE* 54

*SCRIPTITE, LYTRON: Reg. U.S. Pat. Off.

Both hard and slack sized boards are today being laminated with Scriptite 54 adhesive. This water insoluble copolymer works efficiently in conventional laminating systems, producing laminated board that passes 48-hour and longer immersion periods with no delamination. Even when the laminate is forcibly separated, there's a complete fiber pull, no separation at the glue line. With 54, there's no need for heat or long storage curing periods —glue line water resistance sets immediately. For samples and new report, "Laminating Paperboard and Liner Board with Scriptite 54," write: Monsanto Chemical Company, Plastics Division, Room 739, Springfield 2, Mass.

Monsanto

The Monsanto line of paper resins also includes

SCRIPTITE 40 *urea type wet-strength resin.* **SCRIPTITE 33** *melamine wet-strength resin.* **SCRIPTITE 55** *low viscosity resin for improved water resistance, wet and dry rub resistance with easy handling.* **SCRIPTITE 52** *in combination with formaldehyde, gives water resistance to folding boxboard and jute liner.* **SCRIPTITE 50** *unsurpassed printability, improved surface characteristics on boxboard.* **SCRIPTITE 45** *new thermosetting resin for stabilization of paper.* **LYTRON*** *water dispersal resin polymers for coatings.*

FOR IMMEDIATE DELIVERY

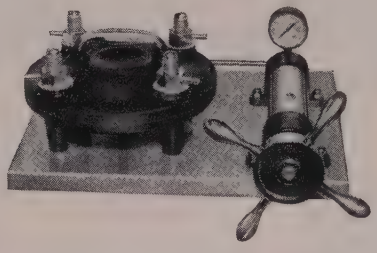
Tappi Standard

Pulp Testing and Sheet Making Apparatus

TAPPI SHEET MAKING MACHINE

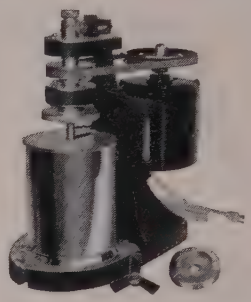
Bronze, brass and stainless construction throughout except couch roll which is heavily chrome plated. Drying Rings with gaskets and Drying Discs available but not illustrated. (T-205 m)

TAPPI PUMP & PRESS



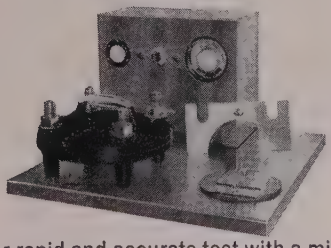
Mounted on 18-8 Stainless steel base. Press on base, or pump only may be purchased separately. (T-205 m)

TAPPI DISINTEGRATOR



Standard equipped with bronze chromium plated container bowl and stainless steel chuck, collet and shaft assembly. (T-205 m)

TAPPI PRESS WITH AUTOMATIC CONTROL

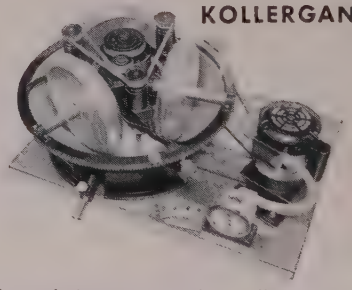


For rapid and accurate test with a minimum of effort. Base and control cabinet 18-8 stainless steel.

AUTOMATIC COUCHING DEVICE FOR SHEET MACHINE and FIBER LENGTH CLASSIFICATION GRID PLATE

(Not illustrated)

IMPROVED PRECISION KOLLERGANG



The only instrument that will give truly reproducible beating results. (T-225 sm)

This line of equipment features the ultimate in pulp testing and sheet making apparatus. Latest improved corrosion resistant material is used on all parts coming into contact with pulp solutions used in testing. The operational precision, durability and beautiful finish will command greater laboratory efficiency and cleanliness. All the Tappi Standard approved apparatus also bears the official seal and registered serial number of the Papermakers Association of Great Britain and Ireland.

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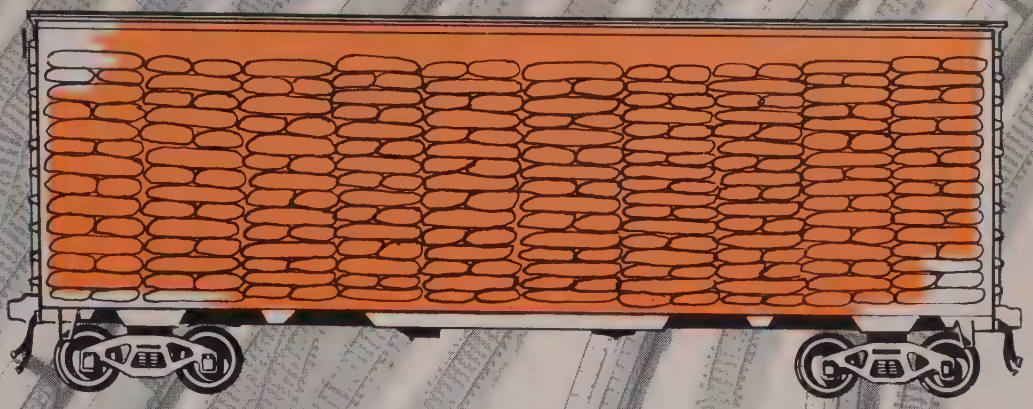
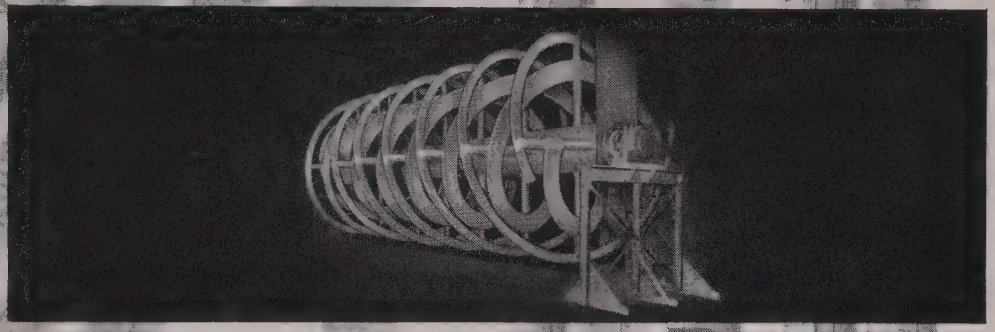


starch uniformity by the carload



from the world's largest blender

New Penick & Ford Blender ensures production quantities at pilot plant tolerances

The big advantage of having your corn starches mixed in the world's largest blender is not size of batch, but the perfect starch uniformity you get . . . up to 60,000 lb. with one bag exactly the same as the next. The blender is part of Penick & Ford's new starch derivative plant which is designed to deliver corn products of improved quality and precise uniformity. With its new facility, P & F can offer industrial starch users production quantities to exact customer specifications, no matter how large or small the order. Call

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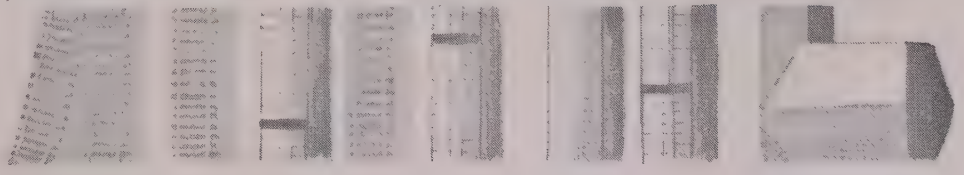

DOW | SARAN LINED PIPE

Saran Lined Pipe carries 140°F. Sulphuric Acid . . . resists shock, temperature changes, corrosion

When a leading paper manufacturer needed a dependable pipeline to carry hot, strong acid waste from its chlorine dioxide bleach plant to a distant kraft recovery system . . . when the pipe had to withstand severe thermal shock, and require a minimum of support and maintenance . . . Saran Lined Pipe was specified as the best answer on all counts.

The Nekoosa, Wisconsin, plant of Nekoosa-Edwards Paper Company installed the chlorine dioxide bleach plant two years ago. Acid waste from the reactor consists of sodium bisulfate dissolved in 35% concentration sulphuric acid. This highly reactive solution enters the Saran Lined Pipe system at 140° F., to be carried to the kraft pulp mill recovery system where both sulphur and sodium are ultimately recovered. The pipeline traverses work areas and pipe tunnels, often being inaccessible for repair and maintenance, and in places is exposed to outside temperatures which can range well below zero in winter.

Because of its extreme corrosion resistance and high physical strength . . . despite conditions of high chemical reactivity, and of thermal and physical shock . . . Saran Lined Pipe continues to perform well for Nekoosa-Edwards, providing completely dependable, maintenance-free performance.

Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200° F. They can easily be cut, fitted and modified in the field without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan, Dept. 2287FC3.

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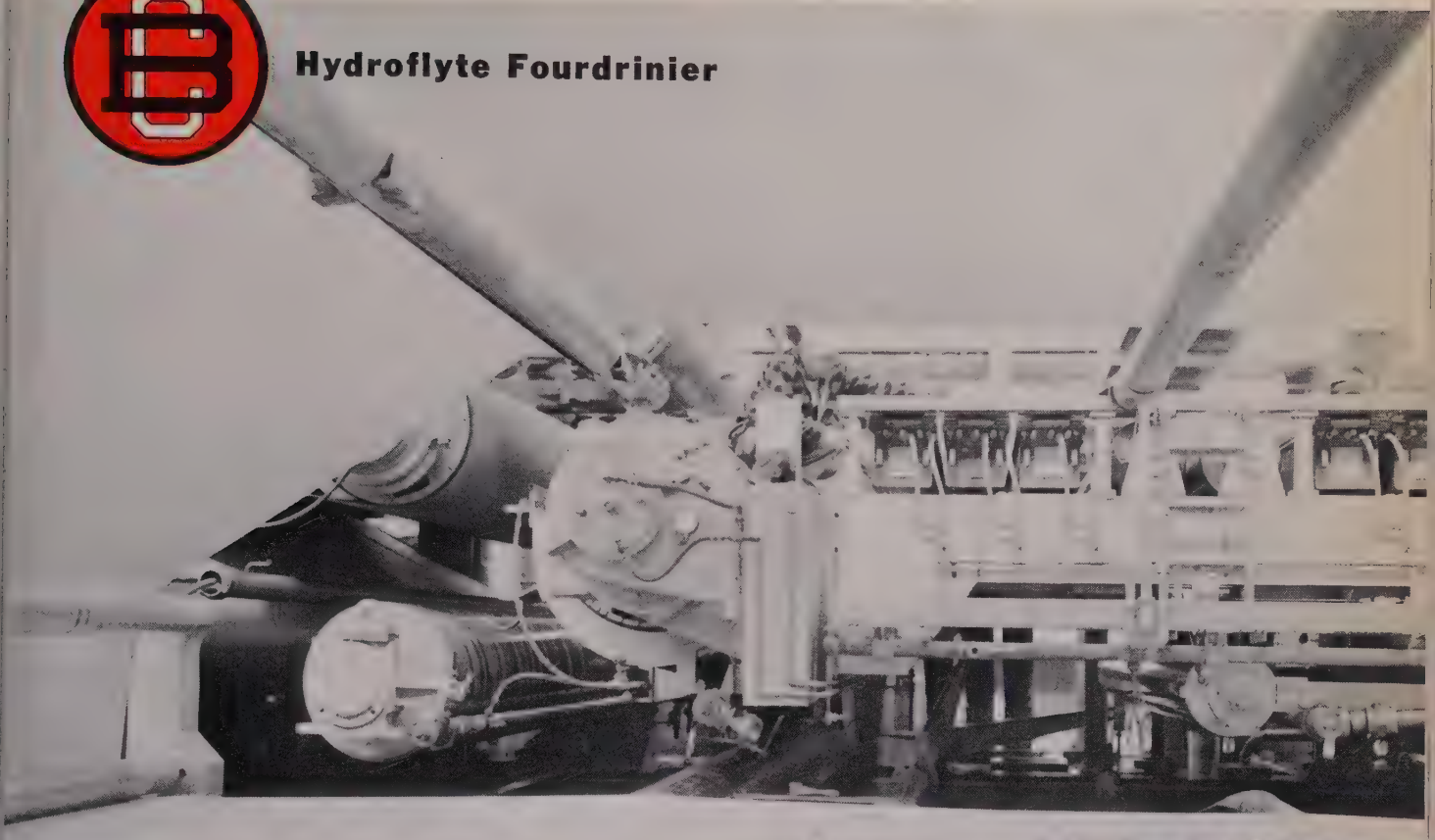
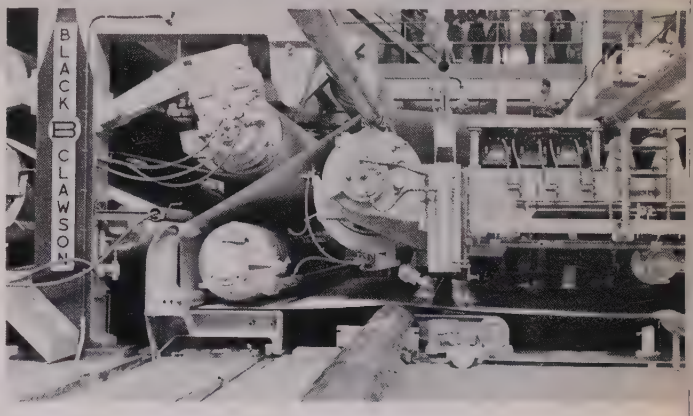
Why Dismantle and Move 125 Tons of Precision Fourdrinier

when it's easier to move a few hundred pounds of wire?

Hydroflyte Fourdrinier

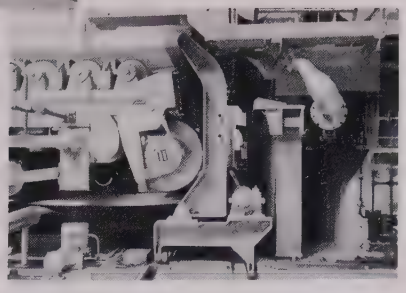


Tensioned wire pre-strung on special rig in aisle alongside Hydroflyte Fourdrinier



Wire is quickly pulled on cantilevered Fourdrinier by winch and cable.

Rolls retracted



Wire in place

Doesn't it make sense to change the wire as quickly and safely as possible? With the Black-Clawson Hydroflyte Permanent Cantilever Fourdrinier you eliminate costly downtime. Suction, air, water, power, saveall, shake and drive connections **are not disturbed in any way.** Positive alignment and precision adjustments are maintained always. Another reason why papermakers who demand the best come to

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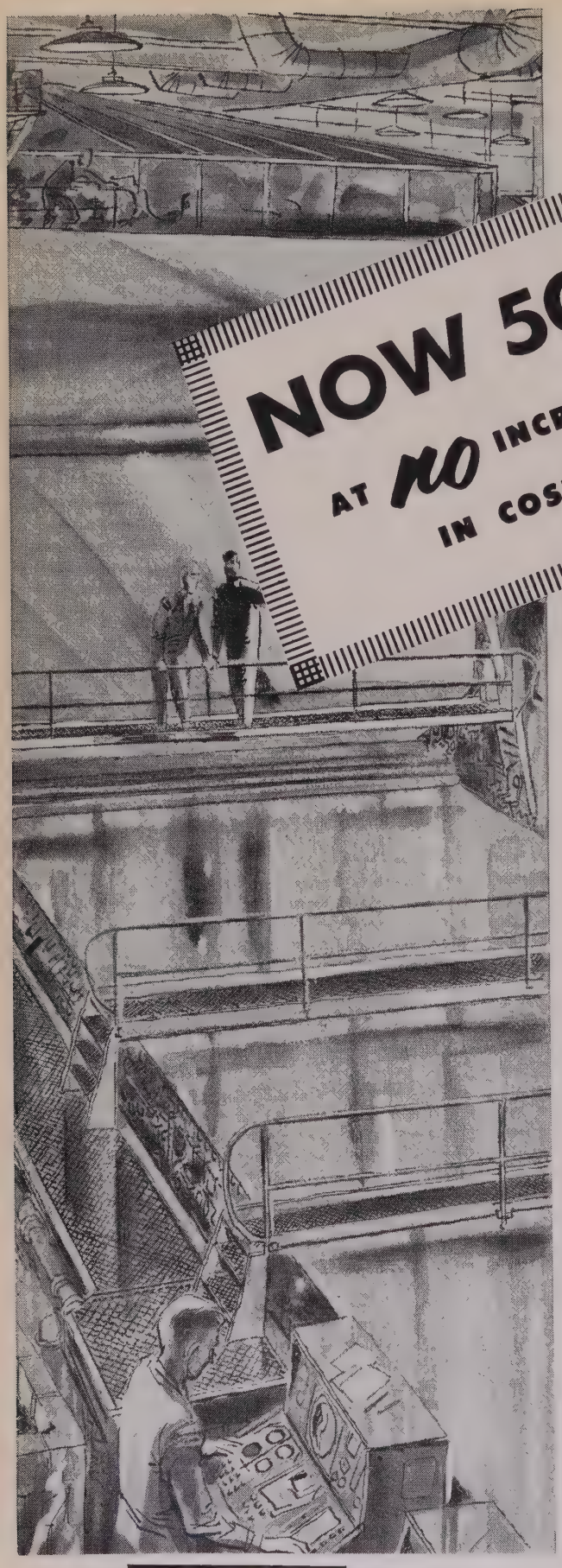
Another Advanced Engineering Design

BLACK-CLAWSON



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V-10...
the perfect slime controllant for all paper mills

Vineland's V-10 insures slime control safely, effectively and continuously.

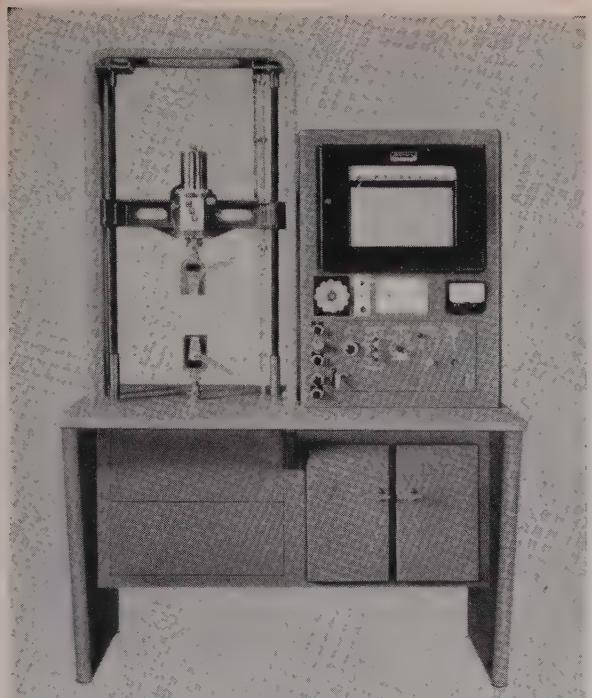
V-10, chemically known as bis-1, 4-bromacetoxy-2-butene is non-toxic, odorless, noncorrosive and economical. Simple to add . . . by slugging once a day . . . V-10 remains effective at high dilution and persists for hours . . . safe* for use in tissue, wadding and food board mills.

V-10 reduces down time. Vineland trained technicians are ready to assist in establishing proper slime control in your mill. Bacterial counts and identifications of micro-organisms will be determined at your request without cost or obligation.

Write or telephone (OX-1-3535) for free booklet, "Control of Slime in the Paper Mill."

* *Test results available on request.*

Vineland Chemical Co.
West Wheat Road, Vineland, New Jersey

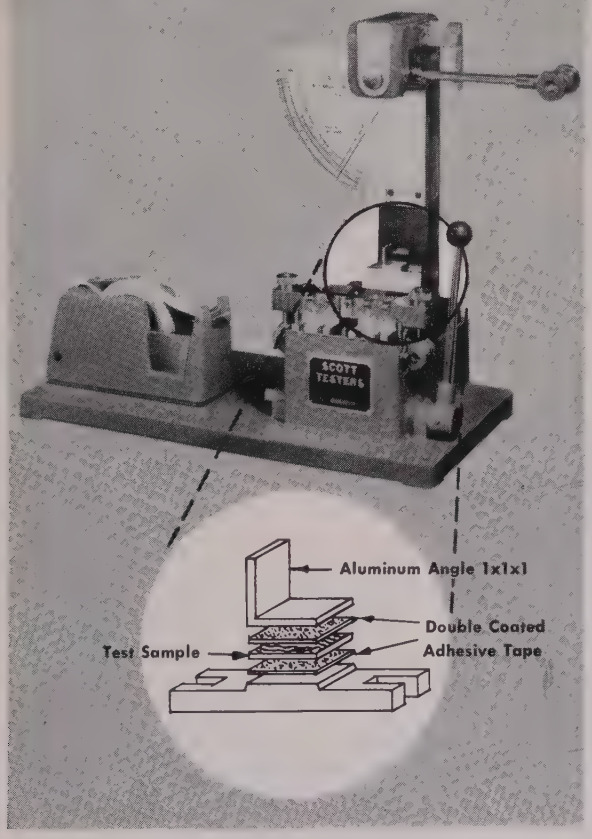


NEW PUSH-BUTTON SIMPLICITY FOR TENSILE TESTING!

Test tensile strength, edge tear, wet tensile, and other physical qualities of your paper products on the versatile Scott Model CRE Constant-Rate-of-Extension electronic tester. New push-button controls make paper testing a simple, fingertip operation . . . offer greater-than-ever operating convenience and testing economies. Ultra-precise *electronic weighing* system provides an infinite variety of crosshead speeds . . . wide selection of test load ranges . . . instant, automatic response to rapidly fluctuating loads.

For detailed test analyses, the ratio of crosshead speed to recorder chart speed can be adjusted to magnify stress-strain curves as high as 400:1. A new Scott clamp-locking assembly also reduces clamp-changing time to a *matter of seconds!* The Model CRE makes use of *all* Scott clamps and fixtures to meet ASTM, ISO, government and paper industry test methods. Most important, the Model CRE gives you this new testing precision, plus new testing simplicity . . . *at surprisingly low cost!*

SCOTT TESTERS FOR PAPER



TEST INTERNAL BOND STRENGTH

Measure the delamination adhesion, inter-fibre bond, ply separation strength of multi-construction papers with the fast, easy-to-work Scott Model B Tester. Its unique design enables the technician to prepare for accurate testing of *five* samples simultaneously . . . *means more tests per hour!* Each sample is split by the impact of a free-swinging pendulum. Direct readings of test values are indicated on a dial recorder. Tester comes complete with fixtures. Two test ranges: 0-.250 and .100-.500 in. lbs.

QUICK-CHANGING SCOTT CLAMPS AND FIXTURES

A-5 CLAMP FOR TENSILE TESTING

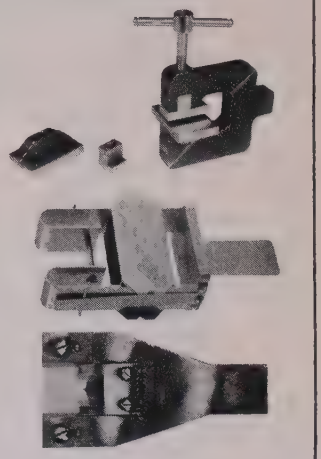
One of many Scott tensile clamps for testing paper — all instantly adaptable to the Model CRE Electronic Tester and other Scott tensile testers. The A-5 clamp features *two* gripping surfaces (1″ or 2″) in direction of test. Pressure on *upper* clamp reduces specimen thickness and minimizes slippage under test. Test capacities to 500 lbs.

FINCH WET TENSILE STIRRUP

Recognized throughout the paper industry, this fixture is adapted from the Finch Wet Tensile Design for use with Scott flat grip tensile jaws. For evaluating reduction in tensile strength of immersed paper specimen in compliance with ASTM Method of Test D-829 and TAPPI Method T-456M.

EDGE TEAR TEST STIRRUP

This fixture is another adaptation from the Finch design for fast set-up and positioning in Scott tensile clamps . . . for testing edge tear resistance of paper. Finished complete with interchangeable clamps of .025″ and .050″ radii. Meets ASTM Method of Test D-827 and TAPPI Method 470M.



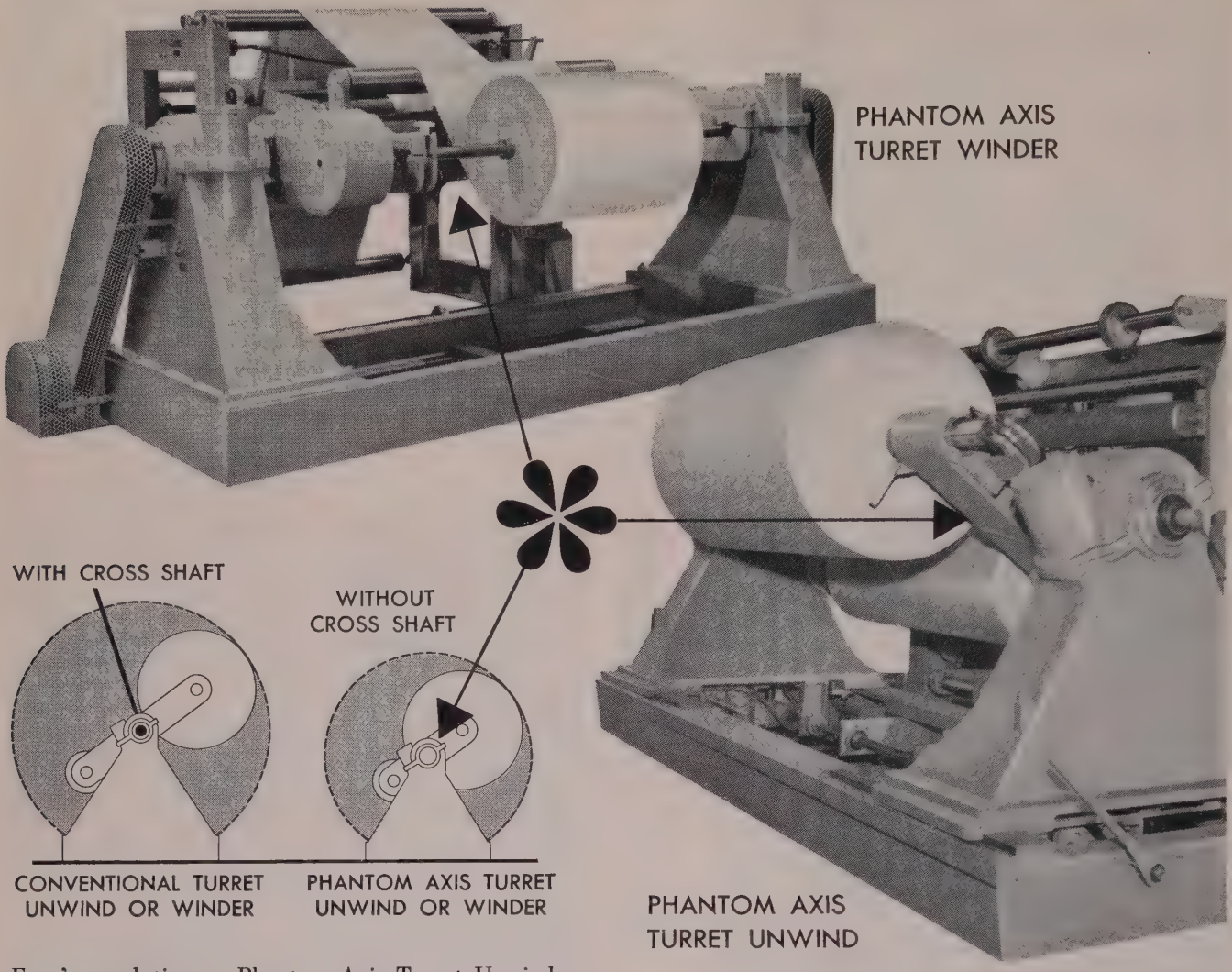
WRITE FOR COMPLETE CATALOGS ON MODEL CRE . . . MODEL B . . . AND SCOTT CLAMPS

SCOTT TESTERS

THE SURE TEST . . . SCOTT!

SCOTT TESTERS, INC.
53 Blackstone Street
Providence, Rhode Island

IT'S WHAT'S NOT THERE THAT COUNTS*



Egan's revolutionary Phantom Axis Turret Unwinds and Winders *eliminate* the center cross shaft for greater roll diameters and more compact overall design. In addition, these units require less overhead and floor space for installation (see drawing).

The more compact design also assures greater rigidity and better operation at high speeds. Phantom Axis Unwinds and Winders are engineered to permit speeds in excess of 1000 fpm; are available in web widths through 120", and include power rotation of the turret and knife cut-off as standard features. Air chucking of cores or shafts is available at the customer's option.

ADDITIONAL FEATURES

PHANTOM AXIS UNWIND: Automatic or manual side shifting; provision for splicing with either inside or outside of web up (optional); flying splices at full machine speed; pneumatic constant tension system (optional).

PHANTOM AXIS WINDER: Side shifting available (automatic or manual); constant or tapered tension; smooth transfers at full machine speed with unique single motor design.

Egan

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ACTION!

WHEN YOU CALL ON NALCO FOR ANTIFOAM SERVICE . . .

First, Nalco has the Antifoam Chemicals to meet pulp and paper mill foaming problems effectively . . . and *second*, when you call your Nalco Field Service Man for service you get *real action!*

Your Nalco Representative has test equipment, chemicals and portable feeding equipment . . . ready to go to work, quickly, to solve your foaming problems. With Nalco antifoams on the job, you will get outstanding air release, better washing of stock and substantial reduction in pitch deposits. And Nalco antifoams will result in better formation and better drainage on the paper machine.

When you want antifoam ACTION, call Nalco.

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THE *Nalco*® SYSTEM

Serving the Paper Industry through Practical Applied Science

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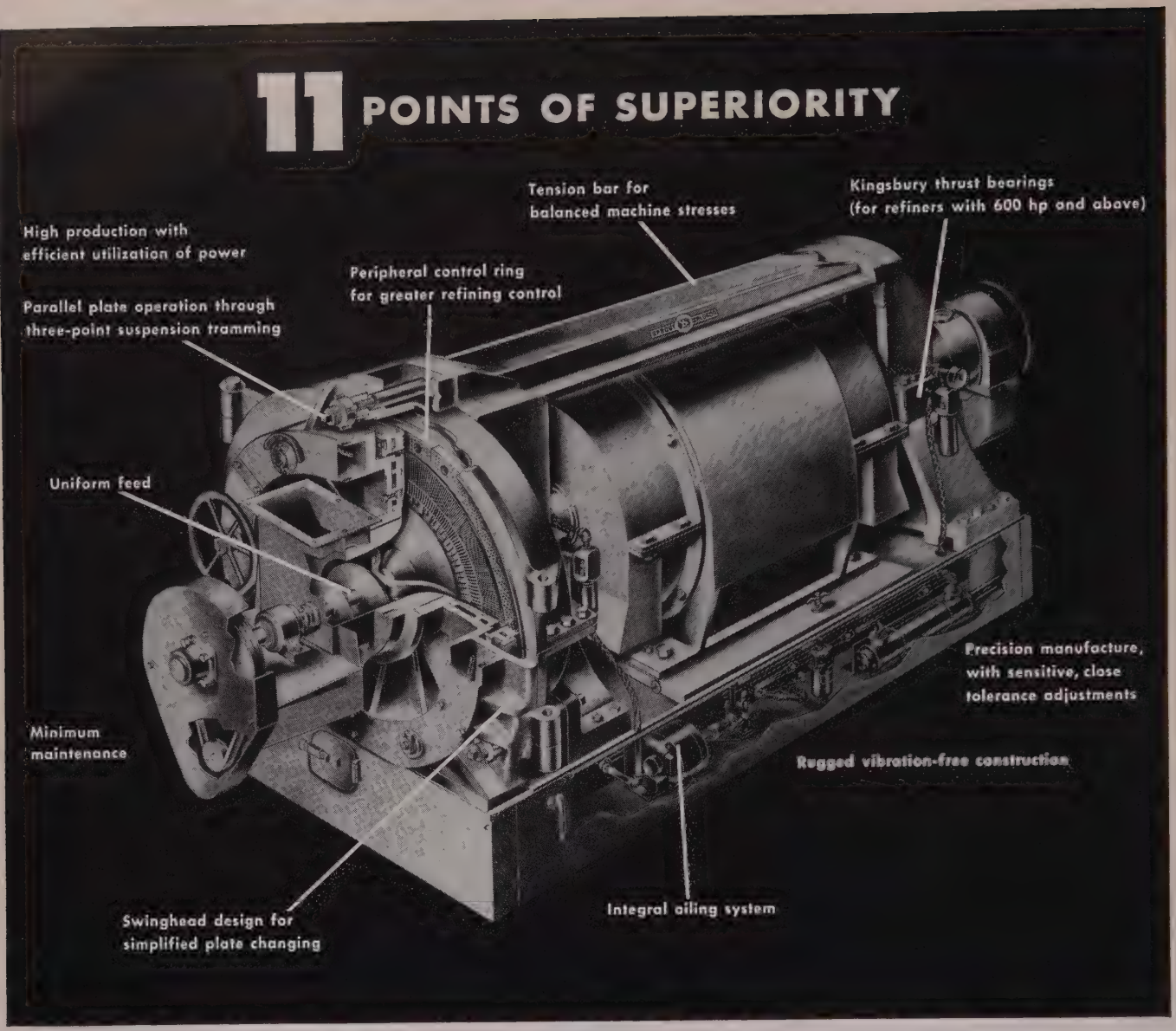
11 POINTS OF SUPERIORITY
Tension bar for balanced machine stresses
Kingsbury thrust bearings (for refiners with 600 hp and above)
High production with efficient utilization of power
Peripheral control ring for greater refining control
Parallel plate operation through three-point suspension tramming
Uniform feed
Precision manufacture, with sensitive, close tolerance adjustments
Minimum maintenance
Rugged vibration-free construction
Swinghead design for simplified plate changing
Integral oiling system

THE WORLD-FAMOUS 36-2 "SPROUT"

single disc precision pulp refiner

The 36-2 Sprout refiner is the most efficient disc refiner in quantity of output and in quality of refined pulp per horsepower input. It is preferred throughout the industry for every pulping application where rubbing and brushing action, without cutting, is required. Sprout-Waldron units lead the field in the refining of semichemical pulp, cold caustic pulp, screen rejects, wastepaper stock; brown stock and hot stock refining of high yield kraft pulp; refining of bagasse, flax and straw pulping; as well as preparation of insulation and hardboard fiber. For the latest details on the 36-2 Sprout, request Bulletin 96-B.

SPROUT, WALDRON & CO., INC.

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SINCE 1866 REFINERS • DIGESTERS • CONVEYORS • FEEDERS • SCREENS • MIXERS • DRAINERS • FIBER PRESSES • STOCK PROPORTIONERS

E/200

DESIGNED . . . TO GIVE MORE MILEAGE!

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Synthetic Reinforced Dryer Felt

RICHLAND 343 combines maximum drying efficiency with the stamina and staying-power of a "marathon runner." It's engineered to endure longer runs where more mileage and real wear-resistance are needed. RICHLAND 343 is a sturdy, fully stabilized felt, constructed to withstand the destructive effects of high chemical concentrations and a great degree of mechanical abrasion. At the same time, it provides the matchless drying characteristics available with cotton felts. Reinforced with synthetic fibers in the warp and filling, RICHLAND 343 will maintain its rugged effectiveness day after day . . . week after week, frequently outrunning asbestos felts and staying on the job so much longer than cotton felts, that it reduces the cost per ton of paper made. Sold only pre-stretched and pre-shrunk, available with or without clipper seams.

MOUNT VERNON DRYER FELT FAMILY RICHLAND 343 is just one of Mount Vernon's full "family" of scientifically designed dryer felts. There's an individual felt for virtually every paper machine position and every paper-making need.

Another Mount Vernon Dryer Felt Success Story . . .

A large producer of newsprint discovered that a tougher, more durable felt was needed for the top position on one of his machines . . . a felt that would withstand high chemical concentrations and speed while still providing efficient drying. Machine speed was 2200 feet per minute with a steam pressure of 40 lbs. Under these conditions, average all-cotton felts lasted approximately 75 days. Mount Vernon engineers recommended RICHLAND 343, a synthetically reinforced dryer felt designed to yield more mileage in hard-working positions. Result . . . 120 days of highly effective running. RICHLAND 343 turned in an outstanding dryer felt performance and remained on the job 60% longer.

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TURNER HALSEY COMPANY
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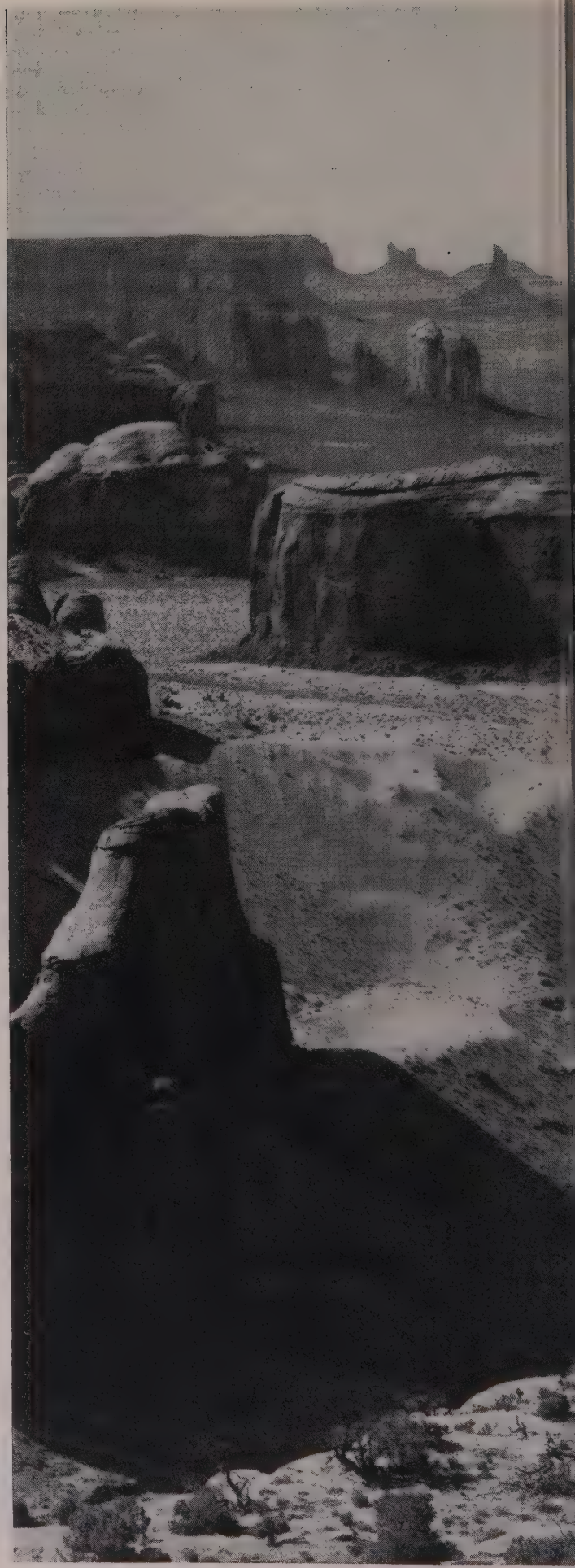
Main Office: 40 Worth Street, New York, N. Y.

Hills and valleys may be beautiful... but not for paper coaters



A paper coater might enjoy this view when he is on vacation, but "hills and valleys" are the last things in the world he wants in the paper he has coated. Perfect smoothness is his aim, and competitive tests indicate he has a better chance of getting it with DYLEX® K-54 latex.

DYLEX K-54 is a new Koppers latex for the paper coating industry. In Gurley Smoothness Tests on identical paper coated with a DYLEX K-54 formulation and competitive latices, the paper coated with DYLEX K-54 had substantially higher ratings at all adhesive levels. Both starch and casein were used in the tests.

In addition to superior smoothness, DYLEX K-54 offers higher pick resistance, excellent mechanical stability and less foam. For more information on formulating better clay coatings with DYLEX K-54, write for our free booklet. Koppers Company, Inc., Plastics Division, Dept. T-30, Pittsburgh 19, Pa.

KOPPERS PLASTICS

KOPPERS

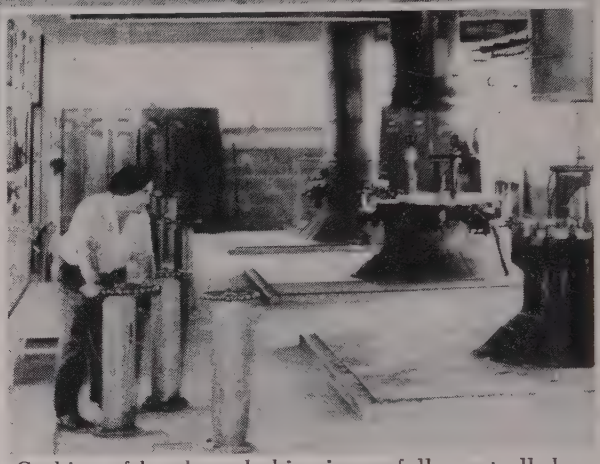
The Cellulose d'Aquitaine mill in Southern France consumes as its principal raw material heretofore unused hardwood species of the area, producing from them high quality bleached pulps.

First pre-hydrolysis kraft pulp mill in France

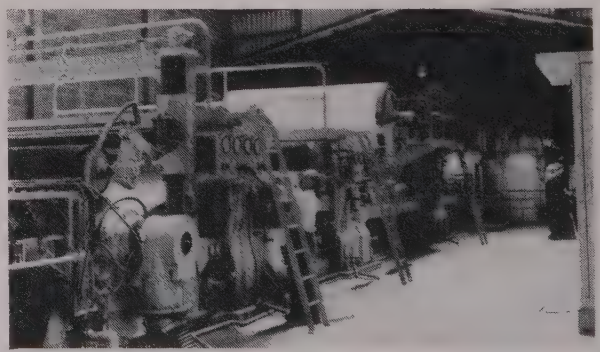
Making France self-sustaining in the production of nitrating grades of cellulose, the mill of Cellulose d'Aquitaine, St. Gaudens, has been in operation since the summer of 1959 and produces up to 120 tons of nitrating pulp or 170 tons of bleached paper grade pulp per day.

The Parsons & Whittemore-Lyddon Organization had full responsibility for design and construction of the plant. It is but one of fourteen mills now in various stages of development for which the Organization provides technical supervision, complete equipment and other important services under a global contract.

Parsons & Whittemore-Lyddon's staff of renowned pulp and paper making experts is backed by the Organization's international machinery manufacturing and sales facilities. Our experts are prepared to assist you in planning, designing, financing, constructing, equipping and operating pulp and paper mills in any country having suitable wood or agricultural fibers. For full information on any or all of these services, write to our nearest office.



Cooking of beechwood chips is carefully controlled on this digester operating floor. Three of the four digesters are shown. All of them are constructed with special alloy lining to permit a pre-hydrolysis cooking stage at extremely low pH values.



The 136" wide Fourdrinier pulp drying machine, built by Black-Clawson, includes cantilever design, modern vacuum equipment and hydraulic press controls.

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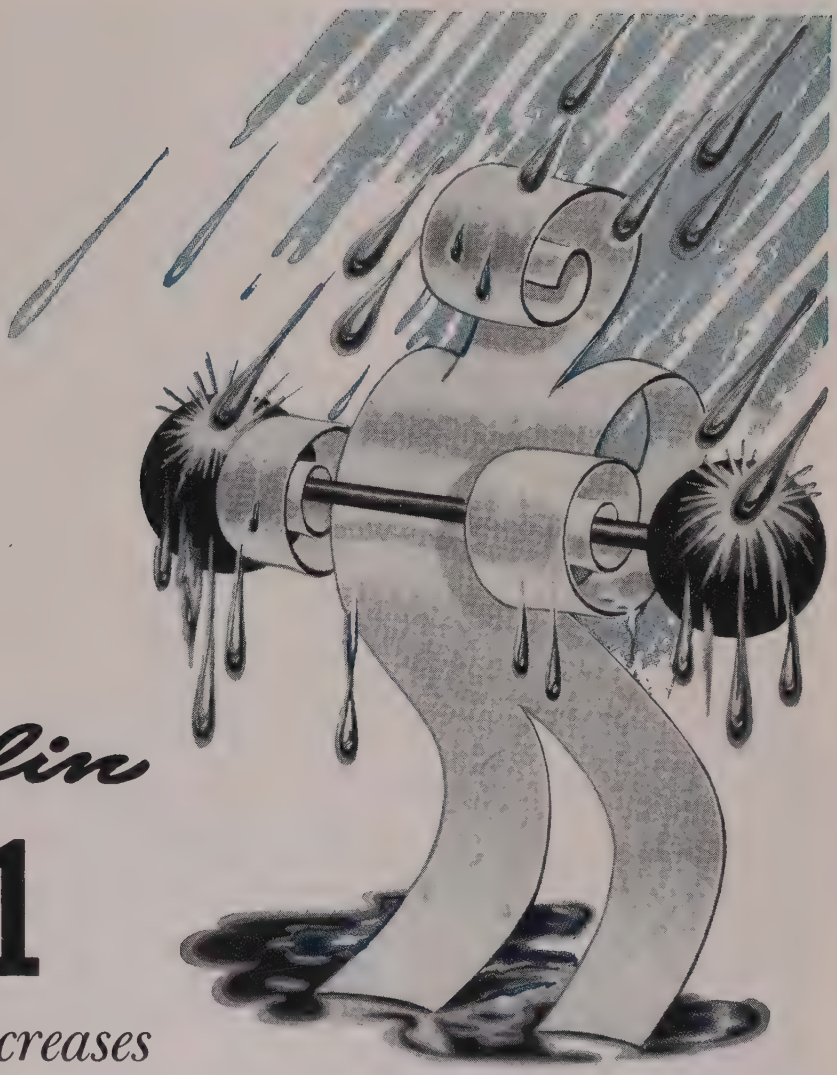

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Because it is more efficient, Catalin Resin 301 . . . a modified, cationic urea-formaldehyde resin . . . can substantially upgrade wet strength with the same percentage of resin solids previously used . . . or cut resin costs by maintaining present wet strength properties with less resin solids. You gain in other ways too . . . Catalin Resin 301 is lighter in color . . . and reacts exceptionally well in the presence of dyes. Dry tensile, mullen and folding endurance is also improved.

Usable in a wide variety of bleached and unbleached pulps, Catalin Resin 301 develops about 50% of its final wet strength as it leaves the machine . . . full cure is reached within 2-3 weeks. Since wet strength is developed slowly, broke can be easily reclaimed.

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New "brain cells" for precision chlorination control

Here's another exciting development from Diamond's customer-service research. These low-cost chlorination cells are rugged, precise, completely dependable . . . give you a simple means of measuring oxidation potential to control chlorine reaction in vessels or sample lines.

No other chlorination cell combines these advantages:

1. Both electrodes are in a single body.
2. Resists virtually every condition encountered in paper mills and other applications of oxidation-potential principle . . . including high pressures and temperatures up to 200° F.
3. Lowers routine maintenance.
4. Reduces down time of automatic control system.
5. Eliminates bridging between electrodes by fibers.
6. Eliminates need for diluting stock or for separate sampling line.

The skill of the Diamond technicians who developed this chlorination cell, the facilities of the Diamond Pulp and Paper Laboratory and thirty years of manufacturing and shipping experience of one of the world's largest makers of CHLORINE and CAUSTIC SODA make Diamond your logical supplier for CHLORINE and CAUSTIC SODA. Call your Diamond Sales Office or write . . . DIAMOND ALKALI COMPANY, 300 Union Commerce Bldg., Cleveland 14, Ohio.

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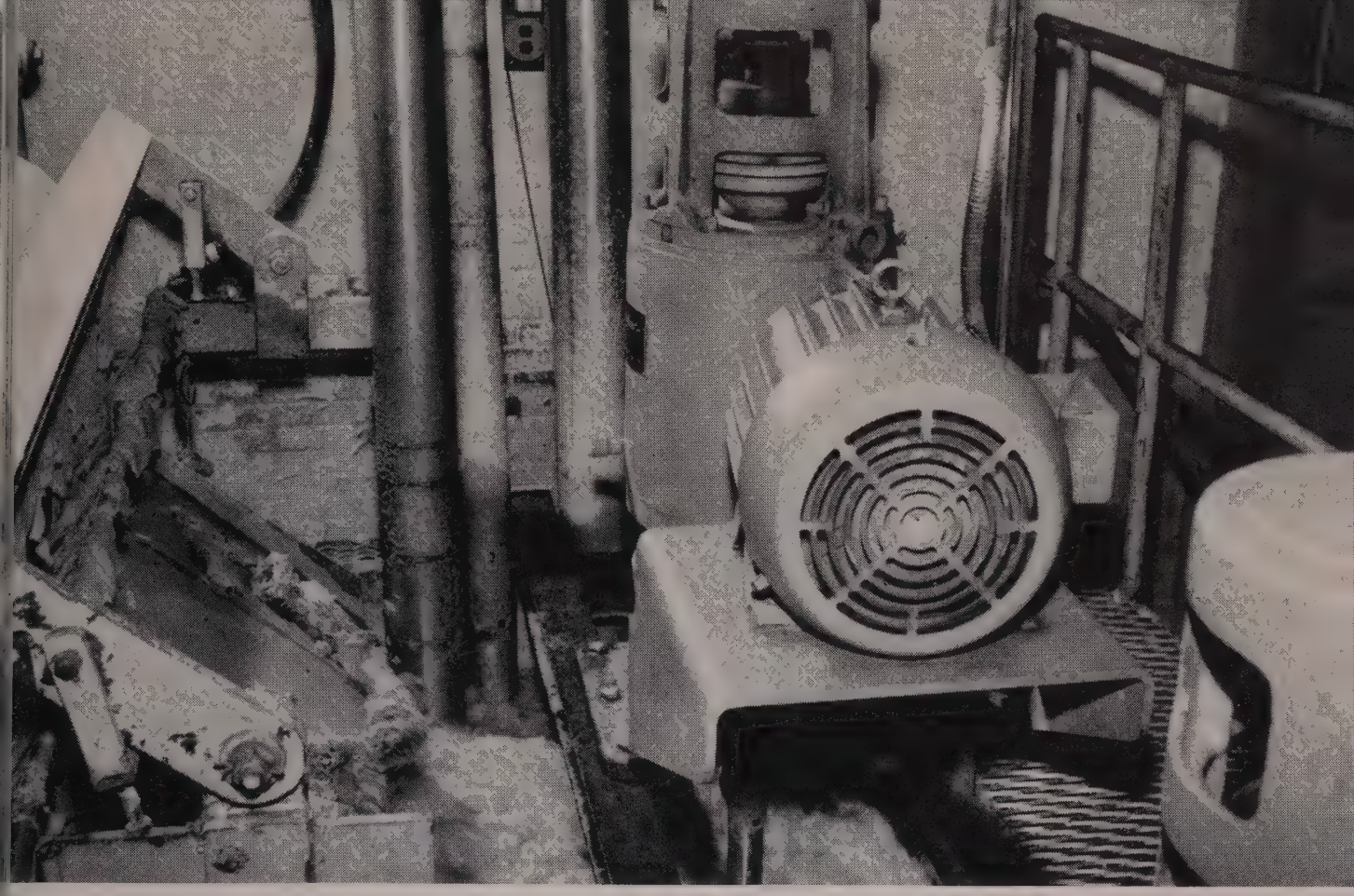


Controlled turbulence created by LIGHTNIN Stock Agitator rapidly separates stock fibers at Gould Paper Co., Lyons Falls, N. Y.

How to make stock uniformity toe the mark

This repulping system gives the mill a tight rein on stock consistency and pH.

Here you see step one. Hardwood stock at a soggy 12% consistency drops from the washers into both ends of a 32-foot-long dilution chest. The tiled chest is 4 feet wide and carries a 4-foot stock level.

Incoming stock meets a stream of acid water recycled from the secondary washer. In each 6-foot-long end section of the chest, the turbine on a 15-hp LIGHTNIN Stock Agitator drives stock and water in a powerful mixing flow.

With this kind of agitation, fiber length and freeness are essentially unchanged. Controlled turbulence does the work of separating the fibers.

Consistency anywhere in this part of the chest stays within 0.1% (bone dry) of the average. Retention time is four minutes.

Rapid pH control Next, uniform stock tumbles over a weir into the 20-foot-long center zone of the chest. Here two more LIGHTNIN Agitators rapidly disperse strong sulfuric acid to bring pH to 2.5 and hold it there as stock discharges to the secondary washer. Uniform consistency and acidity are provided at all conditions up to the design maximum of 4.0% (b.d.).

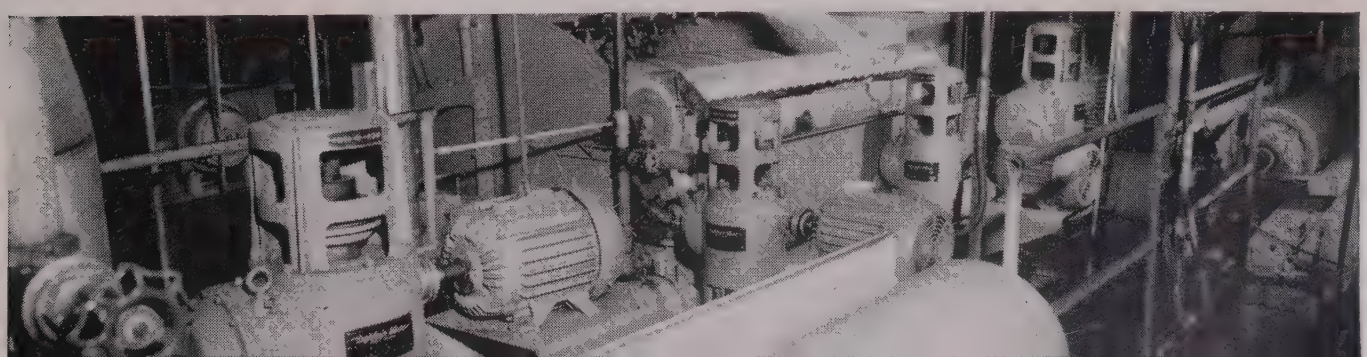
This MIXCO-designed system was delivered to the mill just five weeks after the day it was ordered. It is only one example of the precision control you can bring into your pulping and paper-making operations with LIGHTNIN Agitators in your chests.

To find out more about this kind of mixing and the guaranteed results it gives you, call in your LIGHTNIN representative now. His name is in Thomas' Register and in the yellow pages of your phone directory. Or write us.

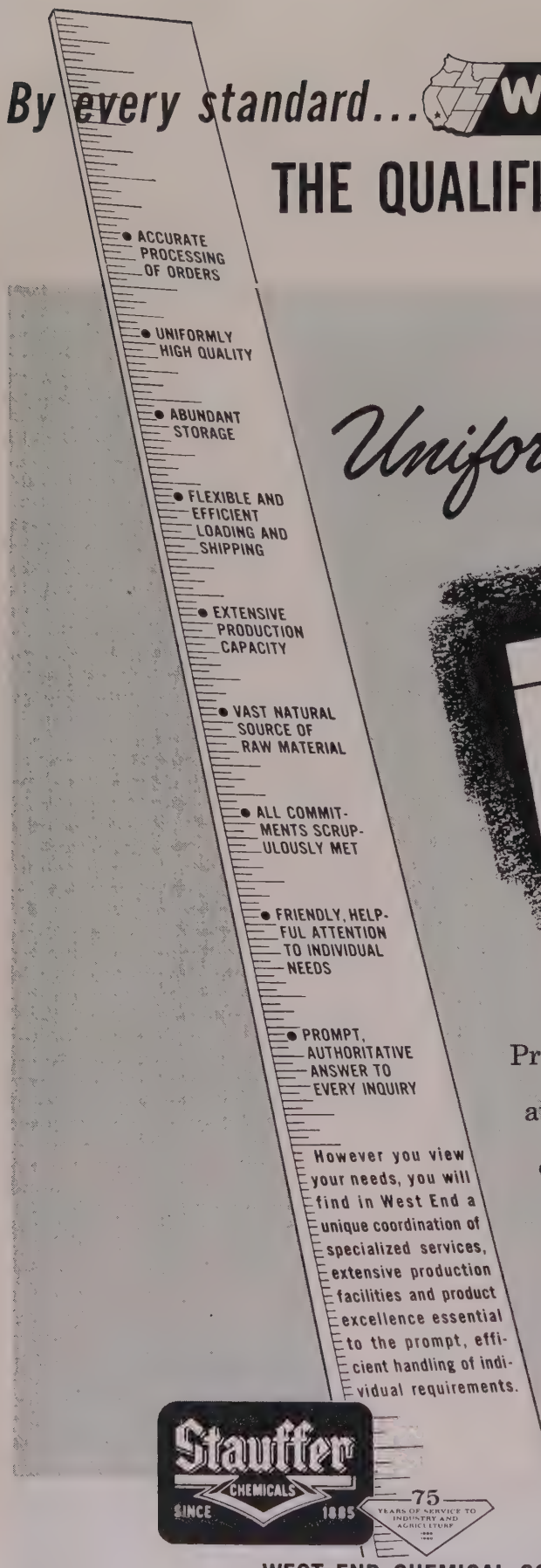
MIXING EQUIPMENT Co., Inc., 142-c Mt. Read Blvd., Rochester 3, N.Y.
In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

Lightnin® Mixers
MIXCO fluid mixing specialists

Dilution chest has repulp sections at ends, pH-control section in center. Installation adapts easily to changes in mill requirements.



By every standard... WEST END MEASURES UP AS THE QUALIFIED SUPPLIER OF SALT CAKE


• ACCURATE PROCESSING OF ORDERS
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• ALL COMMITMENTS SCRUPULOUSLY MET
• FRIENDLY, HELPFUL ATTENTION TO INDIVIDUAL NEEDS
• PROMPT, AUTHORITATIVE ANSWER TO EVERY INQUIRY
However you view your needs, you will find in West End a unique coordination of specialized services, extensive production facilities and product excellence essential to the prompt, efficient handling of individual requirements.

Uniformly high quality

SALT CAKE

TYPICAL ANALYSIS

	Typical %	Guaranteed %
Na_2SO_4	99.57 -99.87	99.5 Min.
NaCl	.06 -.14	.2 Max.
B_2O_3	.03 -.06	.1 Max.
CO_2	.02 -.04	.05 Max.
Na_2O	.05 -.09	.1 Max.
H_2O	.01 -.10	.2 Max.
Insoluble	.001-.01	.05 Max.

Density: Struck Approx. 75 lbs./cu. ft.
Tapped Approx. 88 lbs./cu. ft.

Solution . . . Clear Color . . . White

Production techniques and controls developed at West End maintain the traditional quality of our product, even as we produce it in ever-increasing quantities. We submit West End as a chemical of highest purity and offer the above analysis for your consideration.

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WEST END CHEMICAL COMPANY • DIVISION OF STAUFFER CHEMICAL COMPANY

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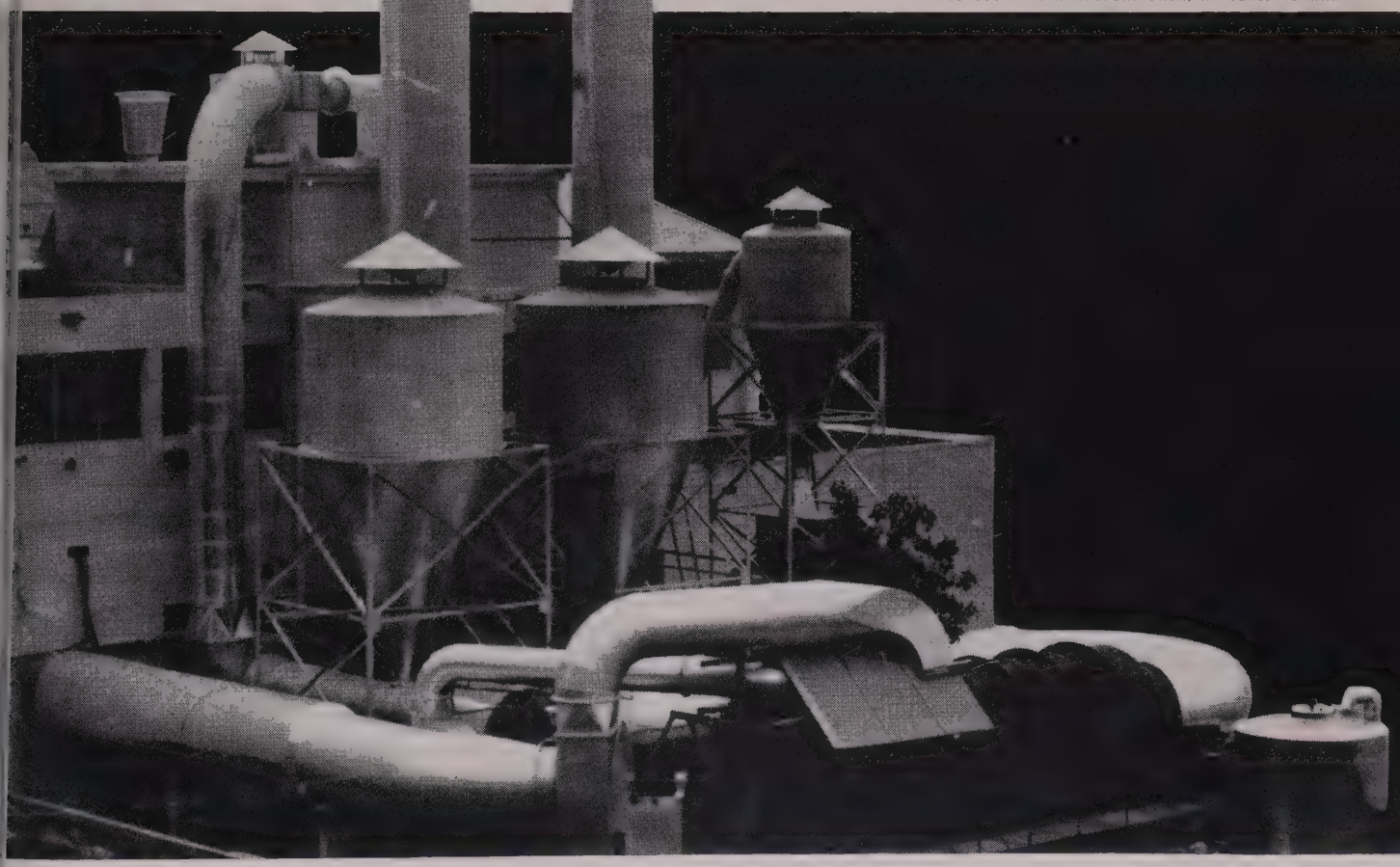
Produce Pulp at less cost per ton with Rice Barton's Fibre-Flash Pulp Dryer

Within 100 mi. of Oslo this pulp mill is producing 100 T.P.D. at impressively low costs.

From stock chest to baler the FIBRE-FLASH system is mechanically far simpler, has a minimum of moving parts and costs less to operate and to maintain than conventional pulp dryers. It conserves every physical characteristic of pulp and is currently being used successfully for both groundwood and chemical pulps.

With our *Pilot Plant* you can see the advantages of drying your pulp the FIBRE-FLASH way. The lower capital investment, the lower installation cost and the smaller amount of space required also make flash-drying the most economical, modern method of drying pulp. Write today for complete details.

PHOTO COURTESY KAMMEFORS BRUK, KRAGERÖ, NORWAY



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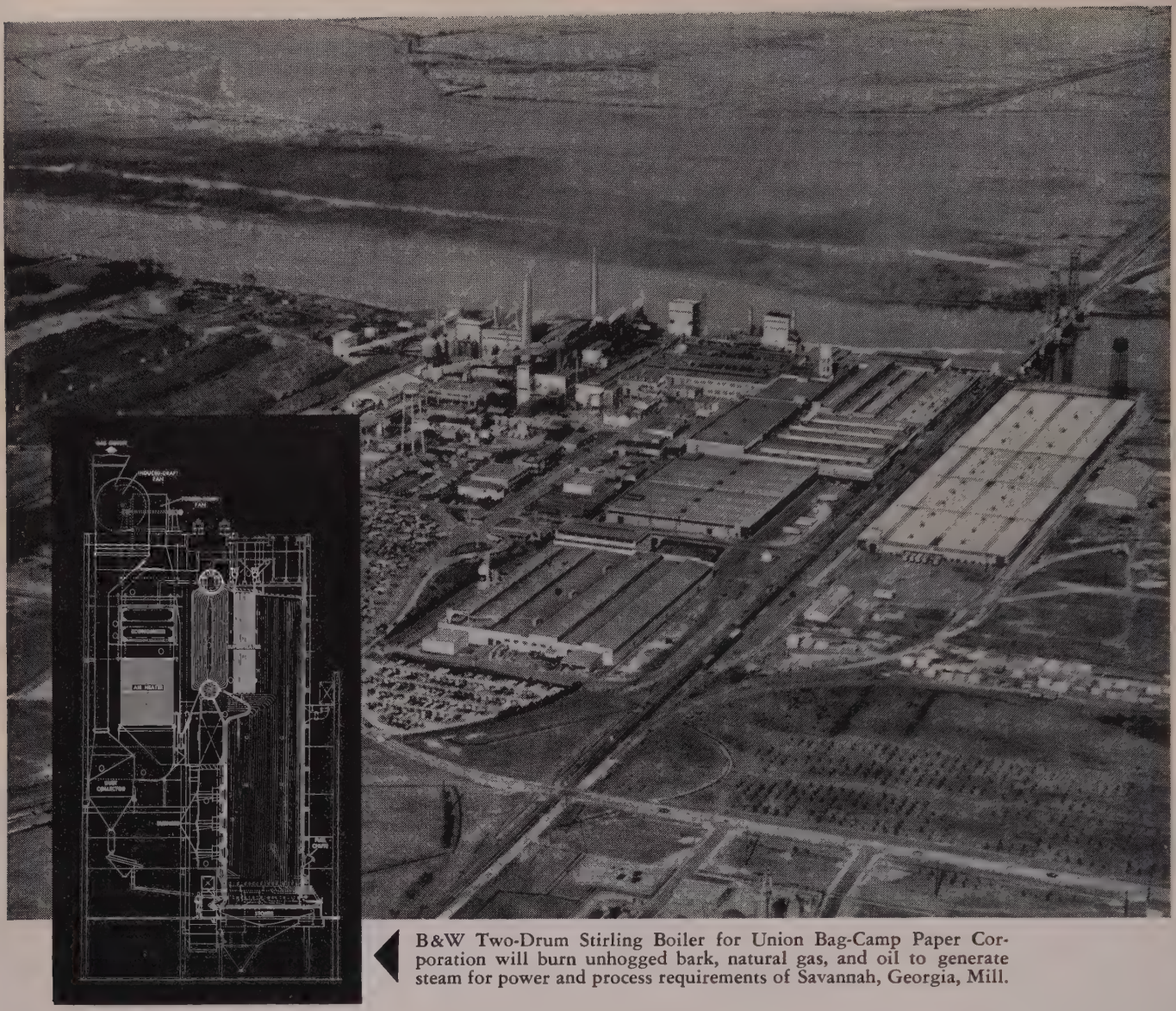
FOURDRINIERS, PRESS SECTIONS, DRYER SECTIONS, CALENDERS AND SUPERCALENDERS, REELS, WINDERS, HEAD BOXES, SIZE PRESSES, BREAKER STACKS, DIFFERENTIAL DRAW CONTROL DRIVES AND CONE PULLEY DRIVES, PULPING EQUIPMENT, HIGH VELOCITY AIR DRYERS, TRAILING BLADE COATERS, FIBRE-FLASH DRYING SYSTEMS



B&W Two-Drum Stirling Boiler for Union Bag-Camp Paper Corporation will burn unhogged bark, natural gas, and oil to generate steam for power and process requirements of Savannah, Georgia, Mill.

Why America's Largest Bark-Burning Boiler is a B&W Boiler

The highest rated bark-burning boiler ever built will soon be generating 550,000 pounds of steam per hour at Union Bag-Camp Paper Corporation's huge mill at Savannah, Georgia. It will burn unhogged bark as a primary fuel but can also be fired with natural gas or oil—singly or in combination with the other fuels. The unit has a design pressure of 1250 psi at the superheater outlet and will operate at 950 F.

The designer and manufacturer? Babcock & Wilcox. Long associated with burning all kinds of fuel for steam generation, B&W has proved time and again its ability to supply dependable and efficient boilers of every size to burn every conceivable kind of fuel. And B&W's manufacturing capacity and know-how assure quick and dependable delivery schedules. That's why profit-minded steam users everywhere choose B&W to solve their fuel burning and steam generating problems.

If you're looking for ways to increase boiler efficiency and achieve fuel economies that will increase your profits, your first step is a talk with B&W. Contact your local B&W sales engineer or write The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

P-822

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

New Emphasis on Ion Exchangers In Paper Making

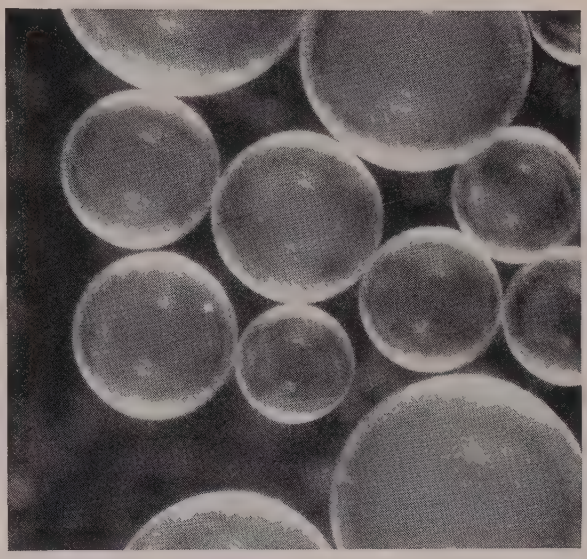
New *Nalcite* resins broaden water treatment scope; make demineralized water practical in wider range of paper mill applications

Bringing ion exchange—and especially demineralization—within the practical range of paper mill water treatment cost, handling and volume requirements is the job now being done with Nalcite Ion Exchange Resins for conditioning a variety of mill waters. Their practicality for these jobs is putting new emphasis on demineralization for producing high quality water at reasonable cost.

New Nalcite resins are new only in that they have recently been released for industry-wide use.

Nalcite HCR-W . . . pretested for four years . . . is a proven cation exchanger of superior physical stability, and is the latest addition to the series of high performance Nalcite resins.

Nalcite SBR-P . . . in slightly more than 3 years since its introduction this highly porous, strong base anion exchanger has surpassed performance expectations.



Nalcite HCR-W under the photomicroscope looks like no other ion exchange resin: clear, perfectly-formed microspheres, stress-free, crack-free, virtually breakage proof in any known ion exchanger service.

Better Water = Better Paper

Demineralized water for *process chemicals preparation* provides a solid base for making uniform solutions which will perform predictably. Other important examples are *aqueous coating solutions* and *dilution water for making electrical condenser paper*. Nalcite-demineralized water, having extremely high electrical resistance, goes far toward helping produce the dielectric strength in finished condenser paper that users want, but not always have been able to obtain.

Steam Production

Demineralized boiler feedwater solves a multitude of steam generation operating and maintenance problems at once. Use of Nalcite Ion Exchangers in modern demineralizing equipment is the surest source of top quality feedwater . . . water that helps produce steam at lowest possible cost.

Higher Physical Stability is Key To New High in Performance

Nalcite HCR-W cation exchanger is teamed with Nalcite SBR-P anion exchanger for top demineralizer performance—in either multiple bed or mixed bed systems. Stress relieved HCR-W bead microspheres are virtually shatterproof. Similar stability of SBR-P assures low pressure losses—and pressure drop stays at design figures since there are no fines to fill spaces between beads or clog strainers, distributors or controls. Backwashing and regeneration are quicker, more efficient with Nalcite exchanger beds.

New Ion Exchange Text Available

Full description and discussion of the many methods of modern ion exchange utilization is contained in Nalcite Bulletin Z-5. Bulletin Z-7 describes new HCR-W. Write for your copies now.

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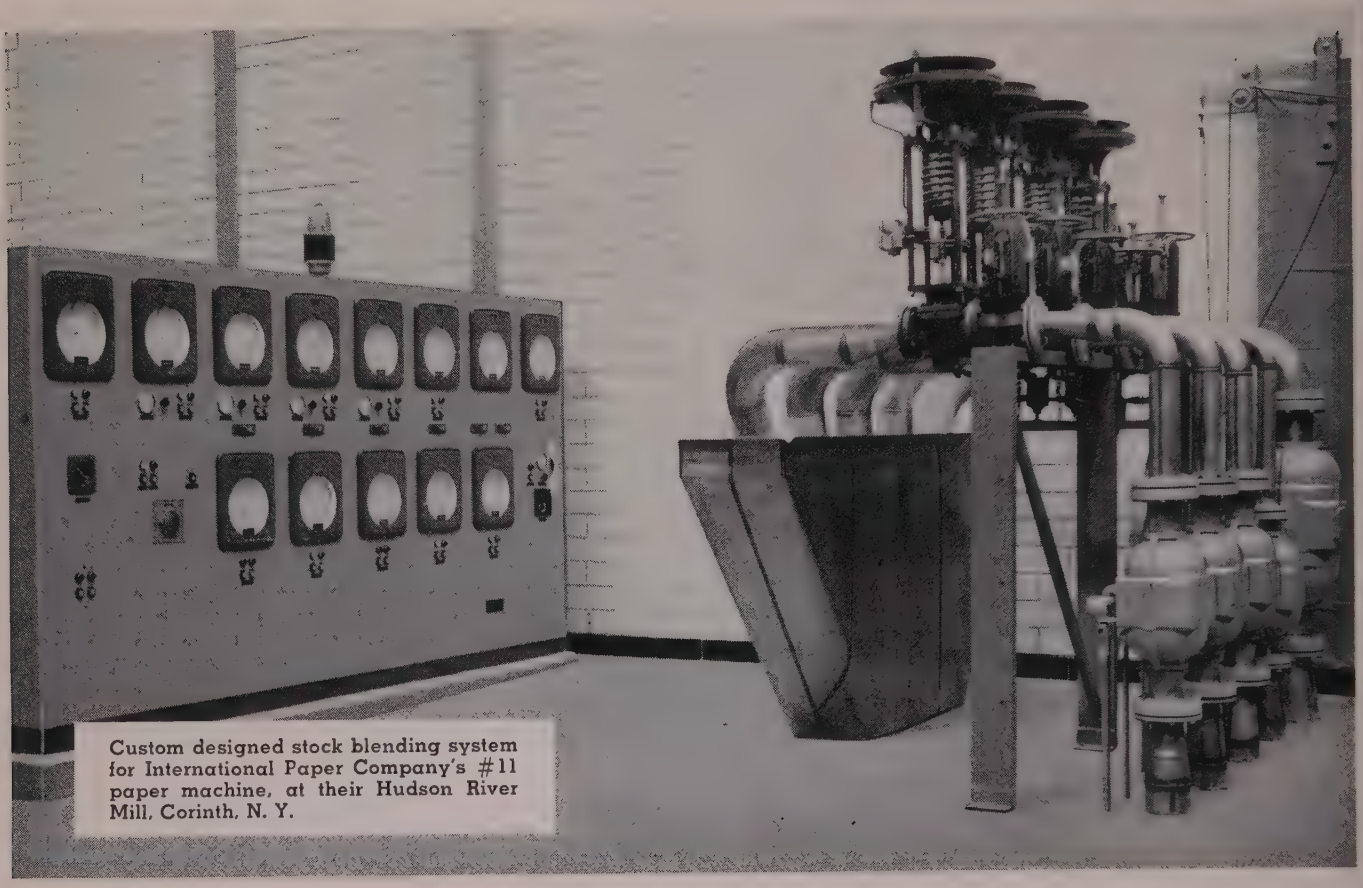
...Serving Industry through Practical Applied Science

Nalco CHEMICALS
Nalcite RESINS

You're looking at the complete pulp stock blending system for a high speed paper machine



Custom designed stock blending system for International Paper Company's #11 paper machine, at their Hudson River Mill, Corinth, N. Y.

Foxboro Magnetic Flow Meters blend all pulp stocks accurately, continuously

Set the proportions for stocks . . . dyes . . . additives and walk away! That's the procedure for changing furnish grades on the Foxboro Stock Blending System at International Paper Company.

With this system, one man at a central panel can blend all 5 pulp stocks — as well as additives and dyes — accurately and continuously.

Each stock percentage is set on its own direct-reading dial — especially selected to meet International Paper's specific operating requirements. Settings are easier — more convenient — more accurate. And the entire system automatically adjusts for changes in machine demand, while all proportions are held exactly constant.

And since all stock measurements are made by the unique Foxboro Magnetic Flow Meter — the meter with no flow restrictions — there is nothing to plug up . . . nothing to interfere with high sustained accuracy of pulp flow measurement.

With Magnetic Flow Meters from 1/10" to 12" and larger, the Foxboro Stock Blending System will handle any number of pulp stocks, dyes, and additives. Every system is custom designed for each mill's own paper-making requirements — resulting in more consistent furnish — higher production. Your mill can benefit from this maintenance-free, space-saving system, too. Write for new engineering data sheet. **The Foxboro Company, 783 Neponset Avenue, Foxboro, Mass.**

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AIRMAIL PAPERS MADE WITH UNITANE® O-110 Titanium Dioxide PUT OTHERS IN THE SHADE!

UNITANE O-110 gives thin papers greater opacity . . . whitens as it brightens. Ask your Cyanamid Pigments representative about UNITANE O-110.

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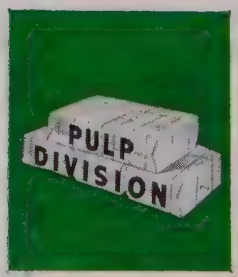
GRAYS HARBOR PULP, COSMOPOLIS, WASH.

Bird's Eye VIEW

The new Grays Harbor Mill, eighty miles south of Tacoma, converts timber into pulp in a continuous operation. From its 10-acre woodyard to finished pulp warehouse, the Grays Harbor operation is under the close supervision of Weyerhaeuser research people who are constantly on the lookout for improved pulping methods.

WEYERHAEUSER



A Search for New Fiber Crops

H. J. NIESCHLAG, G. H. NELSON, I. A. WOLFF, and R. E. PERDUE, JR.

In a continuing search for new fiber-producing plants, a scheme to evaluate their potential as a possible source of papermaking pulp was devised. Included in the evaluation of the plants are their botanical characteristics, chemical composition, dimensional measurements of fibrous constituents, yield after sodium chlorite maceration, and a qualitative physical and visual appraisal. Dimensional and chemical analyses are limited to those necessary for initial evaluation. Data, including density measurements, on 58 plant species representing 11 families are reported. Representatives of the *Gramineae*, *Leguminosae*, and *Malvaceae* appear to be the most promising among the limited number of samples examined.

OF ABOUT 250,000 known species of higher plants relatively few have been, or are now, cultivated to any great extent. This agricultural dependence on a severely limited number of species contributes to our present farm surplus. A new program by the Agricultural Research Service of the U. S. Department of Agriculture is concerned with discovering and investigating the most promising among lesser known members of the plant kingdom, with the object of finding new crops that would be economically attractive and would offer minimum competition to crops now in surplus (*1*). This report concerns that part of the program which is directed toward a search for plants that may have potential as sources of pulp for paper.

The paper industry is almost exclusively dependent on the vegetable kingdom for its raw materials. At present, most papermaking fibers are derived from wood (*2*). However, in areas of the world where wood is less available, other plants, such as bamboo and wheat (straw), are used to make significant amounts of paper (*3*, *4*). With the ever-increasing usage of paper and paper products, greater amounts of fast-growing sources of raw material will be necessary to supply the expanding pulp and paper industry (*5*).

A new fiber crop must fit the technical requirements for processing into pulp of acceptable quality in high yield and must also be adaptable to practical agricultural methods and economically produce a high yield of usable dry matter per acre. It would also be desirable if its growth could be adapted to areas of this country where alternative crops are particularly needed by farmers now producing surplus grains or cotton.

Searching for possible new crops involves the examination of a large number of plant samples. To facilitate such a program, initial tests should be the minimum required to give a reliable indication of pulping potential. Our preliminary evaluation procedure involves consideration of botanical characteristics, chemical composition, dimensions and yield of fibrous constituents, and a qualitative physical and visual appraisal of the plants. Samples are assigned numerical ratings based on an assessment of merit in each of these categories. By adding the numerical ratings from each category, a cumulative value was obtained for each plant material which is indicative of the potential of the species as a pulp crop. This report describes our evaluation procedure and demonstrates its application in the appraisal of 58 plant species.

H. J. NIESCHLAG, G. H. NELSON, and I. A. WOLFF, Northern Regional Research Laboratory, Peoria, Ill. This is a laboratory of the Northern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture. R. E. PERDUE, JR., Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md.

MATERIALS AND PROCEDURES

Collection and Storage

Most of the plant samples were collected in this country from the wild although some were obtained from cultivated, experimental plots. All plants were harvested at or after physiological maturity. On receipt at the screening laboratory, the samples were further air dried if necessary and then stored in a dry location until removed for analyses.

Sampling Plant Materials

Samples for chemical analyses and measurement of cellular dimensions were obtained by random selection of about 1 lb. of whole plant stalk. Seeds, leaves, and roots were not included. Samples for density and dimensional analyses were obtained from plants over 6 ft. by cutting 4-in. segments from the stalk at the bottom (just above the root), the middle, and about $1^1/_2$ to 2 ft. below the top. For plants of moderate height (3 to 6 ft.) only two 4-in. segments were removed: one from the bottom and one about 1 to $1^1/_2$ ft. from the top. If the plant stalks were shorter than 3 ft., one 4-in. segment was taken just below the middle of each stalk. For chemical analyses the remainder of the stalks were rough ground in a Wiley mill equipped with a $^1/_4$-in. round hole screen and then reground using a 1-mm. round hole screen.

The ground samples prepared for chemical analyses were extracted with alcohol-benzene for 16 hr. (*6*). The alcohol-benzene extract was dried, weighed, and then re-extracted with hot benzene. This benzene extract was dried and weighed to give an indication of the amount of lipide present.

The sample remaining after the alcohol-benzene extraction was air-dried and utilized for cellulose determinations. Crude cellulose was determined by the monoethanolamine procedure (*7*) and corrected for ash. Alpha-cellulose was determined by the usual TAPPI Standard (*8*) and corrected for ash and pentosans (*9*). Solubility of the original ground sample in 1% NaOH was also determined (*10*).

Maceration and Cell Measurement

Radial sectors were cut from the 4-in. stalk sections to obtain a representative 1- to 3-g. sample for measure-

ment of cellular elements. The air-dry weight was determined for later calculation of the yield of macerated material. Dicotyledonous samples were physically separated into bast and woody portions and each part separately macerated: monocotyledonous samples were macerated without separation. In cases where separation was difficult, dicotyledonous samples were soaked for several hours in 2% ammonium oxalate to remove pectic substances and thereby facilitate physical separation of the bast and woody portions (*11*).

The prepared sample was subjected to a chemical-physical maceration to separate the individual cellular elements from each other without damage. The chemical treatment is a modification of methods described by Spearin and Isenberg (*12*) and by Jarman and Pickering (*13*). It involves the use of a hot aqueous acetic acid-sodium chlorite solution to remove most of the lignin and other binding materials without appreciable degradation of the cellulosic tissues.

The sample was placed in about 30 ml. of water with 0.5 ml. of glacial acetic acid. About 1 g. of solid, technical-grade sodium chlorite was added for each gram of sample present. This mixture was heated to 65 to 75°C. (in a hood) so that chlorine dioxide was slowly evolved. Small amounts (0.5 to 1 g.) of solid sodium chlorite were added from time to time to maintain the slow evolution of chlorine dioxide. The bast portion of dicotyledons was easily macerated and did not require the lengthy treatment usually necessary for the woody portion or the whole stem of monocotyledons. *Slow* stirring with occasional pressing of clumps of cells against the sides of the container with a smooth glass rod aided maceration of the more difficult materials. A magnetic-stirrer, hot-plate combination with a teflon bar was very effective. Boiling with 1% NaOH for an hour prior to the chlorite treatment helped in maceration of samples like the bamboos which contain a waxy outer layer. Residual sodium hydroxide was removed by washing with hot 5% acetic acid prior to the chlorite treatment.

The chemical maceration was stopped when the cellular bundles were fairly well separated (usually 2 to 6 hr.) although some small clumps still remained. The chlorite liquor was filtered off through hardened filter paper in a Buchner funnel and the cellular material was thoroughly washed with hot water. During washing, it was best to avoid complete drying of the cellular material as this makes resuspension difficult. The slightly wet pad of cellular material was washed from the filter paper with distilled water into a 1-1. Erlenmeyer flask. The volume was brought up to about 500 ml. with distilled water and a few milliliters of 0.5% aqueous Congo red or Safranin dye were added to stain the cells. The mixture was vigorously shaken to disperse the cellular material thoroughly and a small representative portion was quickly poured into a 125-ml. Erlenmeyer flask.

The material in this small flask was subjected to ultrasonic radiation to separate any clumps of cells still present. The ultrasonic generator fed an average power output of 60 w. (240-w. pulse) at 40 kc. to a titanate transducer activating a 0.5-gal. tank about two-thirds-filled with water. The flask containing the sample was placed so that the bottom of the flask was about 0.5 in. below the surface of the water. The generator was then tuned to promote vigorous cavitation within the flask. Ultrasonic treatment was continued until the remaining small clumps were no longer visible. If the chemical maceration was complete, less than 1 min. of ultrasonic treatment was necessary. Ultrasonic treatment was usually necessary for monocotyledons and the woody portions of dicotyledons. Insonation of bast fibers was very brief; in many cases it was not necessary at all. Too long an exposure of bast fibers (or other long fibers) to ultrasonic radiation caused tangling.

Microscope slides of cellular material were prepared from the well-shaken suspension by withdrawing a sample with an 8-mm. i.d. glass tubing (*14*) before the suspension settled. Drops placed on the microscope slide were dried slowly on a thermostatted hot plate at 60 to 70°C. The concentration of the fibrous suspension was adjusted by experience so that the cellular elements were not overly crowded on the slide.

Dried cells on the microscope slide were projected at a magnification of 40× and the lengths of the cellular images were measured with a rule calibrated with a stage micrometer (*15*). Cellular elements longer than 0.1 mm. were measured (*16*); cells shorter than 0.1 mm. and broken fibers were not measured. If the maceration was carefully done, very few broken fibers were normally found. In the few cases where an abnormal number of broken fibers were noted, another sample was prepared.

Fiber widths were obtained by measuring the projected images (160×) at the widest, undamaged segment. The average width of nonfibers (vessels, parenchyma, etc.) was not determined because of the variability in widths of these cells.

For monocotyledons and the woody cores of dicotyledons, fibers, and other cellular elements were measured and cataloged separately. Only bast fibers were measured in the macerated bark of dicotyledons. Arithmetic-average lengths and widths were calculated and were considered to serve screening purposes adequately. Only whole fibers were used in computing arithmetic-average fiber lengths; if broken fibers had been included, the arithmetic average would have been a trivial property depending on the lower limit of length arbitrarily considered (*17*).

We were unable to sample accurately the long bast fibers of *Apocynum cannabinum*, *Asclepias syriaca*, *Cannabis sativa*, and *Ricinus communis* as the end of the 8-mm. glass tubing acted as a screen permitting only the shorter fibers to pass. A representative sample was obtained by pouring part of the macerate into a shallow petri dish. The petri dish was placed on the vertical stage of a low-power projector capable of projecting at a magnification of 10×, the large field necessary for measurement of these fiber images. As average lengths of our samples of these long-fibered materials are meaningless, we report only minima and maxima.

Photomicrographs were taken routinely at 50×.

Yield of Macerated Material

Following measurement of cellular elements the macerated material was collected on hardened filter paper, vacuum dried at 60 to 70°C. and allowed to air-equilibrate overnight at room temperature. The

yield of macerate was calculated as a percentage of the initial air-dry weight of the whole sample. For monocotyledons a total yield of macerate was determined. For dicotyledons bast and woody yields were computed separately and, since both were based on the original sample weight, their sum was the total yield.

Density of Plant Stalks

The previously cut 4-in. segments from the various plant stalks were used as samples to measure density. Those selected were center-cut longitudinally into two or more parts to obtain a small bundle of material about 1 in. or less in diameter when loosely held together. (Chips of the bamboo culms were used in place of 4-in. segments.) The sample was weighed to the nearest milligram.

A 1-ft. length of stainless-steel rod about $^1/_8$ in. in diameter was silver-soldered perpendicular to the center of a circular, 40-mesh, stainless-steel screen of the proper diameter to fit freely inside a 100-ml. graduated cylinder. A calibration mark was painted on the rod about $^1/_2$ in. from the screen. The 100-ml. graduated cylinder was filled with 60 to 70 ml. of mercury and the screen plunger inserted and forced rapidly down and up keeping the screen below the surface of the mercury to remove any trapped air. With the screen still below the surface, the calibration mark on the rod was positioned at the top of the meniscus while the volume was estimated to the nearest 0.1 ml. The screen plunger was carefully removed without loss of mercury and the sample was placed in the graduated cylinder. The screen plunger was reinserted on top of the sample and used to force it below the surface, again pumping down and up to remove trapped air. With the calibration mark on the rod even with the meniscus, this volume was read. The weight, in grams, divided by the difference in volume gave the density in grams per milliliter.

ASSIGNMENT OF RATINGS

Botanical Evaluation

The species selected were classified in five groups according to their probable adaptability to growth in the United States and probable yield of vegetative matter. This evaluation applies to the suitability of the species as potential agronomic crops, planted and harvested by practical agricultural methods. The most promising species were rated 1; the least promising 5. These ratings are listed in Tables III and IV. Basis for the classification is as follows:

Rating 1: Terrestrial herbs 5 ft. or more tall, upright in habit, of mesic to subxeric environments, which can be grown in temperate or subtropical regions. All bamboos of temperate or subtropical regions that attain a height of 5 ft. or more.

Rating 2: Terrestrial herbs 2 to 5 ft. tall, upright in habit, of mesic to subxeric environment, which can be grown in temperate or subtropical regions. All bamboos of temperate or subtropical regions that attain a height of 2 to 5 ft.

Rating 3: Terrestrial herbs less than 2 ft. tall, upright in habit, of mesic to subxeric environment, which can be grown in temperate or subtropical regions.

Rating 4: True tropical annual and perennial herbs and bamboos. Marsh plants.

Rating 5: Woody plants (trees and shrubs), vines, true aquatics, strict xerophytes, epiphytes, parasites, succulent tufted plants with few or extremely slender stems, rosette plants with few or extremely slender stems, and sod-forming grasses.

Chemical Analyses

The chemical analyses of samples investigated are presented in Tables I and II. Values obtained were used to assign numerical ratings to the various samples primarily on the following basis:

Rating	*Crude cellulose, %*	*Alpha-cellulose, %*	*Soluble in 1% NaOH, %*
1	≥50	≥34	≤32
2	44 to 49	29 to 33	33 to 39
3	<44	<29	>39

A sample was given the highest numerical rating when its analytical constants satisfied any two of the three chemical criteria enumerated. In most cases the properties have sufficient interrelationship that all three standards for any given category will be met.

In developing the limits for these ratings, chemical analyses of both acceptable and unacceptable pulping materials were taken into consideration. Under this system both hardwoods and softwoods would be rated 1. Wheat straw with average analyses of about 50% crude cellulose, 34% alpha-cellulose, and 38% alkali solubles would also be rated 1. Hop-vines, for example, with analyses of 42% crude cellulose, 29% alpha-cellulose, and 43% alkali solubles, have been shown to be unacceptable pulping material (*18*); under this system they would be rated 3.

Cell Dimensions

Average cellular dimensions, also listed in Tables I and II, were calculated from a combined bast and woody average fiber length for dicotyledons as follows:

$$\text{Combined fiber length (mm.)} = \frac{(\bar{b} \times B) + (\bar{w} \times W)}{T}$$

where

$\bar{b}$ = average bast fiber length, upper limit, 3.00 mm.
B = per cent bast maceration yield
$\bar{w}$ = average woody fiber length
W = per cent woody maceration yield
T = per cent total maceration yield

If $\bar{b}$ was less than 3.00 mm., the actual average was used in the calculation; if greater, the limit of 3.00 mm. was imposed to avoid the "weighting" effect of higher average lengths. Although the limit selected for $\bar{b}$ is somewhat arbitrary, the need for a rational limit is justified since long fibers are normally broken or shortened during pulping procedures to avoid clumping during sheet formation. Long fibers of bleached, unbeaten, sulphite pulp with an average length above 3 mm. have been shown to cause difficulties during sheet formation that result in decreased strength (*19*).

This calculated fiber length for dicotyledons is comparable to the average fiber length of monocotyledons; both were used to assign numerical ratings as follows:

Rating	Average fiber length
1	≥1.00 mm.
2	0.75 to 0.99 mm.
3	<0.75 mm.

Limits for the fiber length rating were also arbitrarily selected and may need revision when information from actual pulping trials with these plant materials is obtained. Fiber lengths are not unequivocally related to paper strength properties; the minimum length necessary to produce acceptable paper depends upon many factors. Certain bamboos are known to be

Table I. Data on Monocotyledoneae

Material	Where collected	Material-soluble in alcohol-benzene: Dissolved out of residue with hot benzene, %	Material soluble in 1% NaOH, %	M.E.A. cellulose, %	Alpha-cellulose basis original materials, %	Density, g./ml.	Arithmetic averages: Fiber length, mm.	Length of all cells mm.	Fiber width, μ	Maceration yield, %
Gramineae										
Andropogon gerardi	Kansas	5.7	1.4	39.9	52.2	33.4	0.38	1.15	0.63	13.7	56.0
Andropogon hallii	Kansas	5.8	1.5	39.1	52.7	33.5	0.33	0.99	0.50	14.7	47.7
Andropogon intermedius	Kansas	5.7	1.5	42.8	50.0	31.5	0.40	0.94	0.43	11.4	49.5
Arundo donax	Maryland	10.2	2.7	43.8	46.0	29.3	0.44	1.18	0.62	12.1	54.7
Bambusa vulgaris	Brazil	5.0	0.7	25.8	55.2	36.3	0.68	2.30	1.26	15.3	52.9
Guadua amplexifolia (base)	Mexico	5.8	0.6	32.2	58.2	40.6	0.46	1.29	0.72	15.5	47.2
Guadua amplexifolia (middle)	Mexico	3.7	0.4	28.5	60.9	42.8	0.65	1.43	0.81	17.2	49.1
Guadua amplexifolia (top)	Mexico	4.1	0.3	29.5	61.6	43.0	0.74	1.51	0.84	14.5	51.7
Guadua angustifolia	Ecuador	3.6	0.3	37.3	52.1	29.8	0.85	1.83	0.68	12.6	51.0
Gynerium sagittatum	Honduras	3.2	0.6	29.9	58.4	38.5	0.48	1.04	0.68	11.4	54.1
Lygeum spartum	Spain	7.7	...	42.5	49.1	34.5	0.60	1.54	0.62	11.8	46.6
Miscanthus sinensis	Maryland	6.7	1.1	39.8	52.3	35.5	0.36	1.09	0.55	9.3	51.3
Pennisetum spicatum	Georgia	14.1	1.0	46.1	46.2	30.2	0.34	1.26	0.59	12.2	46.7
Pennisetum typhoides	Missouri	16.1	1.0	54.4	40.1	26.0	0.24	1.19	0.54	12.7	45.0
Phyllostachys bambusoides (base)	Georgia	5.8	0.3	23.6	58.0	35.5	0.76	1.46	0.93	13.5	51.7
Phyllostachys bambusoides (middle)	Georgia	5.9	Trace	22.5	57.7	36.6	0.83	1.23	0.88	12.1	50.5
Stipa coronata	California	8.0	2.4	48.2	44.6	26.4	0.48	0.81	0.46	10.8	41.2
Stipa speciosa	California	7.8	1.3	44.4	45.8	27.8	0.42	0.91	0.45	15.0	40.1
Stipa splendens	Nebraska	10.6	2.7	46.5	42.2	27.2	0.49	0.85	0.48	10.0	42.0
Stipa tenacissima	Spain	4.2	2.0	33.1	60.5	47.8	0.84	1.08	0.64	10.6	53.7
Stipa viridula	N. Dakota	8.6	2.0	43.5	47.2	29.4	0.56	1.07	0.57	10.3	44.8
Sorghum almum	Illinois	12.7	0.8	40.8	54.9	36.3	0.28	1.46	0.74	13.9	55.4
Sorghum vulgare (grain)	Texas	11.9	2.8	49.6	46.0	29.4	0.22	0.70	0.42	12.9	52.0
Sorghum vulgare (broom corn)	Texas	8.2	1.3	44.3	52.1	32.5	0.25	0.93	0.44	12.7	51.2
Sorghum halepense (forage)	Maryland	7.4	2.1	41.7	52.0	33.2	0.30	1.30	0.68	13.3	53.0
Tripsacum dactyloides	Maryland	14.7	1.1	49.0	39.6	25.5	0.36	1.25	0.48	14.5	46.1
Zea mays[a]	Illinois	12.1	0.7	46.7	50.4	34.2	0.29	1.52	0.62	16.0	52.5

[a] Fibrous residue from a variety of corn under study because of the high sugar content in its stalks. Before sampling for analysis, the juice was expressed.

good pulping materials and, according to our rating system, would be classified as acceptable with a rating of 1. Although fiber-width and length-width ratios are also contributing factors affecting paper quality, these were not included in this preliminary evaluation scheme, even though available from the data.

Maceration Yield

Maceration yields (Tables I and II) were also converted to numerical ratings. The total maceration yield of both monocotyledons and dicotyledons was rated 1, if 50% or over; 2, if between 40 and 50%; and 3, if less than 40%. A sample of spruce, a representative softwood, had a total maceration yield of 52% while maple, a hardwood, yielded 58%; both would be rated 1.

Qualitative Inspection

As each accession was sampled for analysis, it was inspected and rated by a panel of five technical workers. Their rating was based on a qualitative visual and physical estimation of the amount of pith, strength of bast, proportion of bast, and texture of the woody portion (or the whole stalk of monocotyledons) considering its hardness and fibrous nature. The samples were rated as (1) promising, (2) questionable, and (3) not promising. The ratings of the five inspectors were averaged and included in the total evaluation of the samples as the "Individual Inspection" (Tables III and IV).

Total Point Value

By adding the point evaluation ratings (Table III and IV) from each category, a cumulative value was obtained for each plant material. Materials having a total point value of 8 or less were considered as potential pulping materials meriting additional study. Those with ratings of 9 and 10 show some slight promise and may warrant additional study as time permits. Samples with point ratings of 11 or higher were considered unsatisfactory and no additional work with them is contemplated.

DISCUSSION

Although our rating system has merit for initial screening it does not give unequivocal evidence of pulping potential; verification by experimental pulping will be necessary. However, the point ratings will be most useful in selection of materials for small-scale pulping studies. Evidence that the ratings give essentially valid indications is included in the discussion by plant families. Possibly, an occasional sample may be so outstanding in one particular aspect that it should be considered for pulping even though it does not appear promising on the basis of its total point value.

Certain features of the screening program, though not included in the point rating system, are important in a broader, more general appraisal of plant materials. Examination of the bast-fiber length and maceration

Table II. Data on Dicotyledoneae

Material	Where collected	Material soluble in alcohol-benzene: %	Material soluble in alcohol-benzene: Dissolved out of residue with hot benzene, %	Material soluble in 1% NaOH, %	M.E.A. cellulose, %	Alpha-cellulose basis original materials, %	Density, g./ml.	Arithmetic average lengths, mm.: Bast fiber	Woody fiber	Combined bast and woody[a]	All woody cells	Arithmetic average widths, μ: Bast fiber	Woody fiber	Maceration yield: % Bast	% Woody	% Total
Apocynaceae																
Apocynum cannabinum	Maryland	9.9	2.0	36.8	45.3	29.5	0.48	8.5–25.0[b]	0.45	1.31	0.36	19.0	18.4	17.1	33.7	50.8
Asclepiadaceae																
Asclepias syriaca	Nebraska	8.2	3.4	39.4	46.1	31.2	0.51	2.0–19.5[b]	0.48	1.31	0.34	22.0	27.3	14.2	28.9	43.1
Caprifoliaceae																
Sambucus canadensis	Nebraska	9.5	1.9	31.5	44.8	27.9	0.49	0.61	0.73	0.72	0.39	19.8	19.1	6.3	44.1	50.4
Compositae																
Achillea millefolium	California	8.0	1.5	39.7	44.2	28.0	0.52	1.14	0.45	0.61	0.32	14.1	20.6	10.6	35.0	45.6
Ambrosia artemisiaefolia	Connecticut	8.6	1.1	39.1	44.9	28.0	0.65	0.96	0.45	0.65	0.37	11.5	14.9	11.4	17.6	29.0
Ambrosia trifida	Nebraska	3.4	0.9	32.9	48.4	30.3	0.44	1.10	0.46	0.50	0.34	17.3	19.9	2.8	47.6	50.4
Cirsium discolor	Maryland	7.5	1.8	44.7	42.1	27.2	0.45	0.90	0.63	0.70	0.41	22.2	19.2	12.4	33.3	45.7
Helianthus annuus	Nebraska	7.2	1.1	36.9	46.9	30.5	0.33	2.03	0.60	0.77	0.36	21.9	22.5	6.6	49.2	55.8
Helianthus grosseserratus	Kansas	6.5	1.6	39.2	46.2	29.4	0.43	1.14	0.74	0.83	0.41	21.7	22.9	12.3	40.9	53.2
Helianthus maximiliani	Kansas	10.1	1.9	40.9	42.4	26.8	0.58	1.17	0.50	0.60	0.32	15.3	16.8	5.9	35.5	41.4
Helianthus rigidis	Kansas	13.9	5.5	51.3	37.3	23.3	0.74	1.11	0.58	0.70	0.39	20.1	21.1	7.7	25.1	32.8
Helianthus salicifolius	Kansas	17.4	3.9	49.3	37.2	29.9	0.76	1.15	0.47	0.58	0.35	11.1	18.1	5.5	29.2	34.7
Helianthus tuberosus	Nebraska	6.4	1.6	33.7	48.5	31.1	0.38	1.31	0.52	0.56	0.32	14.6	19.6	2.6	43.2	45.8
Lactuca canadensis	Maryland	11.3	1.6	47.1	42.3	29.4	0.33	1.37	0.68	0.70	0.44	16.9	21.2	1.3	37.5	38.8
Silphium integrifolium	Kansas	8.3	1.3	39.3	43.3	27.0	0.57	1.44	0.53	0.75	0.32	16.6	20.1	13.0	40.5	53.5
Silphium laciniatum	Kansas	10.1	5.1	45.6	39.7	25.1	0.65	1.66	0.66	1.12	0.39	17.3	20.6	22.6	26.8	49.4
Solidago sempervirens	Maryland	7.9	2.6	39.3	44.3	27.1	0.56	1.48	0.44	0.60	0.30	13.2	15.1	7.3	38.9	46.2
Solidago gigantea v. leiophylla	Connecticut	7.9	1.2	34.3	48.7	31.5	0.43	1.28	0.50	0.56	0.37	14.3	19.6	4.5	49.6	54.1
Euphorbiaceae																
Acalypha virginica	Maryland	15.4	1.5	47.4	44.0	27.8	0.66	4.92	0.52	0.86	0.39	21.6	19.2	5.5	34.8	40.3
Ricinus communis	Nebraska	2.5	1.3	32.7	49.7	34.0	0.33	5.0–13.6[b]	0.72	1.10	0.38	39.4	27.1	9.4	47.1	56.5
Leguminosae																
Crotalaria juncea	Illinois	3.3	1.4	31.2	54.1	37.9	0.35	3.79	0.58	0.95	0.39	23.3	23.4	9.4	51.4	60.8
Crotalaria juncea (Brazilian)	Illinois	3.3	1.2	28.7	55.4	39.2	0.30	3.80	0.61	1.09	0.40	26.8	30.2	12.6	50.3	62.9
Crotalaria juncea (ridged stem)	Texas	5.1	0.6	29.3	54.6	36.3	0.37	3.57	0.57	1.00	0.41	27.6	26.9	7.4	34.9	42.3
Crotalaria juncea (smooth stem)	Texas	4.3	0.7	30.5	53.7	35.6	0.42	3.61	0.60	0.92	0.39	27.9	28.6	6.6	42.7	49.3
Desmanthus sp.	Kansas	5.6	1.5	34.5	46.8	31.0	0.35	1.87	0.43	0.76	0.34	21.4	16.6	12.9	42.8	55 7
Desmanthus illinoensis	Nebraska	5.6	1.1	33.6	49.0	31.7	0.46	1.46	0.43	0.64	0.35	18.2	23.4	9.1	36.0	45.1
Sesbania cinerescens	Georgia	6.4	1.6	38.8	44.8	30.3	0.36	2.34	0.62	0.96	0.47	18.9	24.2	9.0	36.5	45.5
Sesbania sonorae	Arizona	3.3	0.5	27.8	54.1	36.3	0.33	2.35	0.55	1.00	0.41	16.8	22.0	12.0	36.2	48.2
Malvaceae																
Abutilon theophrasti	Maryland	9.4	1.2	43.6	42.8	27.6	0.32	1.30	0.57	0.76	0.39	21.2	28.7	13.6	39.4	53.0
Althaea rosea	Maryland	6.5	1.0	36.8	47.9	30.5	0.32	1.93	0.71	1.06	0.40	15.2	24.8	15.0	36.7	51.7
Hibiscus cannabinus (Avg. value)	Illinois	3.7	...	30.9	53.8	34.7	0.26	2.6	0.50	1.34	0.30	18.0	22.0	20	30	50
Hibiscus cannabinus (hurds)	Florida	3.4	...	29.4	52.2	34.0	0.16	...	0.54	...	0.31	...	37.2	...	...	42.3
Hibiscus esculentus	Nebraska	5.0	1.4	45.6	35.4	23.3	0.39	2.43	0.92	1.35	0.47	30.1	31.3	12.3	31.3	43.6
Hibiscus esculentus (pods only)	S. Carolina	5.3	3.2	36.8	52.8	34.7	0.46	...	1.00	...	0.64	...	25.7	...	...	62.7
Hibiscus sabdariffa	California	9.1	...	37.8	48.6	32.3	0.28	2.27	0.68	1.35	0.41	17.0	26.4	21.4	29.6	51.0
Moraceae																
Cannabis sativa	Illinois	4.0	0.9	30.1	56.2	37.6	0.33	2.4–20.0[b]	0.57	1.06	0.39	21.4	26.7	10.2	40.4	50.6
Polygonaceae																
Polygonum persicaria	Connecticut	7.7	1.1	34.7	43.0	29.0	0.57	1.85	0.58	0.90	0.40	17.3	22.1	11.8	35.3	47.1
Umbelliferae																
Cicuta maculata	Maryland	4.3	1.2	34.4	48.9	31.6	0.28	1.48	0.55	0.56	0.35	15.4	18.4	0.4	35.5	35.9
Heracleum lanatum	Maryland	5.9	1.4	36.2	45.6	30.4	0.18	0.92	0.69	0.72	0.36	14.8	20.1	5.8	33.9	39.7

[a] Calculated value, see text.
[b] Minimum and maximum lengths.

yield of bast indicate that some of these plants may have potential for cordage or textile use or as a source of long fiber for specialty papers. The benzene extract, referred to in the chemical procedures section, gives ancillary information that may be useful in our general screening program. This fraction may contain interesting waxy constituents which are potentially useful by-products if the species were used as a pulping material.

The density of these plant stalks is of interest as it is a factor which will affect the economics of harvesting, transportation, storage and process equipment capacity. The values reported are useful for comparison and preliminary evaluation but do not take into account the void space present in the central portion of many stalks or the voids that would be associated with storage and handling. It is difficult to assess accurately the bulkiness of a material without knowing the form in which it will be stored, shipped, or processed; in fact, a material could have different bulk during the various stages of utilization. Because of these complications, density values were not included in the point ratings. For comparison, the density (gram per milliliter) of a sample of spruce chips was 0.49; maple chips, 0.70; and straw 0.31 by our procedure.

Photomicrographs of four macerates (Fig. 1) illustrate extremes in woody-fiber lengths of docotyledons

Table III. Point Evaluation Ratings: Monocotyledoneae

Sample	Botanical evaluation	Chemical composition	Rating by fiber dimension	Individual inspection	Maceration yield	Total point value
Gramineae						
Gynerium sagittatum	1	1	1	1	1	5
Phyllostachys bambusoides	1	1	1	1	1	5
Zea mays[a]	1	1	1	1	1	5
Miscanthus sinensis	1	1	1	2	1	6
Sorghum almum	1	1	1	2	1	6
Stipa tenacissima	2	1	1	1	1	6
Andropogon gerardi	1	2	1	2	1	7
Arundo donax	1	2	1	2	1	7
Sorghum halepense	1	2	1	2	1	7
Bambusa vulgaris	4	1	1	1	1	8
Lygeum spartum	3	1	1	1	2	8
Pennisetum typhoides	1	3	1	1	2	8
Sorghum vulgare (broom corn)	1	2	2	2	1	8
Sorghum vulgare (grain)	1	2	2	2	1	8
Stipa viridula	2	2	1	1	2	8
Tripsacum dactyloides	1	3	1	1	2	8
Andropogon intermedius	1	2	2	2	2	9
Guadua amplexifolia	4	1	1	1	2	9
Guadua angustifolia	4	2	1	1	1	9
Stipa splendens	1	3	2	1	2	9
Andropogon hallii	1	2	2	3	2	10
Pennisetum spicatum	2	2	1	3	2	10
Stipa coronata	2	3	2	2	2	11
Stipa speciosa	3	3	2	1	2	11

[a] Fibrous residue from a variety of corn under study because of the high sugar content in its stalks. Before sampling for analysis, the juice was expressed.

and fiber lengths of monocotyledons encountered in this study. In these photographs no bast fibers of dicotyledons are shown.

The average woody-fiber length of *Solidago sempervirens* is less than half that of the *Hibiscus esculentus;* their fiber widths are in about this same ratio. The average fiber length of *Bambusa Vulgaris* is almost three times that of *Stipa coronata,* but the average fiber width is only one-third greater for the longer fibered material. These differences are apparent in the photographs. For fibers of the same length, monocotyledons usually have narrower fibers than woody fibers of dicotyledons and, accordingly, higher length-width ratios.

The screening program shows relationships between members of the same botanical family, where several have been analyzed. This information will guide selection of additional genera and species for future screening from families that appear promising. Each family here represented is briefly discussed in the following paragraphs.

Apocynaceae. Only one member of the dogbane family, *Apocynum cannabinum,* was rated. Although deficient in some respects, it had exceptionally long bast fibers and a bast fiber maceration yield of 17.1%. The bast fiber of this species is reported to be sufficiently similar to that of flax (*Linum usitatissimum*) to be spun and woven into fabric (*20*).

Asclepiadaceae. The only member of the milkweed family thus far analyzed, *Asclepias syriaca,* is somewhat similar to *Apocynum cannabinum* in that its most outstanding characteristic is long bast fiber. Use of this bast as a textile fiber has also been suggested (*20*).

Caprifoliaceae. The only representative of the honeysuckle family included, *Sambucus canadensis,* does not appear promising, although it did have a good, average woody-fiber length (0.73 mm.). Although the average bast length was unusually short, the bast fibers tend to resist separation from their long fiber bundles so that their effective length may be appreciably longer than that of the ultimate fiber cells. This family has little promise as the great majority of the species are woody and would have low crop potential.

Compositae. Fifteen different members of the composite family were analyzed. One species had a total point value of 8, and five had a rating of 9. Only three of these had an alpha-cellulose content of 30% or over; these may have some pulping possibility. The remainder show practically no potential.

Silphium lacinatum is of some interest because of its high maceration yield of bast fiber (22.6%). *Helianthus grossesserratus* had a good average woody-fiber length (0.74 mm.); *H. annuus* had a fairly good bast fiber length (2.03 mm.). These two *Helianthus* species indicate some possible potential for this genus. The suitability of *H. annuus* for the manufacture of paper and dissolving pulps has been reported (*21*). The family as a whole does not show a great deal of promise.

Euphorbiaceae. The two members of the spurge family that were analyzed, *Ricinus communis* (castor) and *Acalypha virginica,* have excellent bast fiber length. The bast of *Ricinus* has been mentioned in the literature as a possible cordage fiber (*22*). This material has a good point rating, 6, and experimental pulping of the whole plant stalk is reported to yield acceptable book paper (*22*). Castor bean has been suggested as a dual-purpose crop in the Gulf Coast Region where the seed would be utilized for the production of oil and the stalk as a source of cellulose (*23*). The leaves are reported to contain a powerful insecticide (*24*). The *Euphorbiaceae* may be a promising family.

Gramineae. Of the monocotyledons, only the grass family is represented. Among these grasses, the bamboos which can be grown in the Southern States rank high. Bamboo is the principal papermaking raw material of India and is known to yield high-quality pulp, reportedly superior to that of tropical hardwoods (*25*). *Stipa tenacissima* (esparto), widely used

in England, is also said to be an important source of fiber for the Spanish paper industry (*26*); it had a total point rating of 6 in our evaluation. Selected sorghums show promise as pulping materials (*27*, *28*), and fairly good writing paper is reported to have been made from broom corn fibers (*29*). Although cornstalks (*Zea mays*) have been used to produce satisfactory insulating board, 9-point corrugation box board, and, in combination with wood fibers, various grades of paper (*30*, *31*), their use in this country has been discontinued as uneconomical.

mucronata and C. spectabilis also indicate that this genus has good possibilities as a source of raw material for pulp and paper manufacture (*32*). The alpha-cellulose content of all members of this family was high; the poorest member had over 30%. One would expect high-pulp yields from this group.

Malvaceae. The mallow family, especially the genus *Hibiscus*, appears very promising. *H. esculentus* (okra), although of poor chemical composition, had a higher average woody-fiber length (0.92 mm.) than any other dicotyledon. The bast fibers of *H. cannabinus* (kenaf)

Table IV. Point Evaluation Ratings: Dicotyledoneae

Sample	Rating by: Botanical evaluation	Chemical composition	Fiber dimension	Individual inspection	Maceration yield	Total point value
Apocynaceae						
Apocynum cannabinum	2	2	1	2	1	8
Asclepiadaceae						
Asclepias syriaca	1	2	1	2	2	8
Caprifoliaceae						
Sambucus canadensis	1	3	3	2	1	10
Compositae						
Helianthus grossesserratus	1	2	2	2	1	8
Ambrosia trifida	1	2	3	2	1	9
Helianthus annuus	1	2	2	3	1	9
Helianthus tuberosus	1	2	3	2	2	9
Silphium laciniatum	1	3	1	2	2	9
Solidago gigantea v. leiophylla	1	2	3	3	1	9
Helianthus maximiliani	1	3	3	2	2	10
Silphium integrifolium	2	3	2	3	1	11
Achillea millefolium	2	3	3	3	2	12
Cirsium discolor	1	3	3	3	2	12
Solidago sempervirens	1	3	3	3	2	12
Ambrosia artemisiaefolia	1	3	3	3	3	13
Helianthus rigidis	1	3	3	3	3	13
Helianthus salicifolius	1	3	3	3	3	13
Lactuca canadensis	1	3	3	3	3	13
Euphorbiaceae						
Ricinus communis	1	1	1	2	1	6
Acalypha virginica	2	2	2	3	2	11
Leguminosae						
Crotalaria juncea (Brazilian)	1	1	1	1	1	5
Crotalaria juncea	1	1	2	1	1	6
Crotalaria juncea (ridged stem)	1	1	1	1	2	6
Sesbania sonorae	1	1	1	1	2	6
Crotalaria juncea (smooth stem)	1	1	2	1	2	7
Desmanthus sp.	1	2	2	2	1	8
Desmanthus illinoensis	1	2	3	1	2	9
Sesbania cinerescens	5	2	2	2	2	13
Malvaceae						
Hibiscus cannabinus (avg. value)	1	1	1	1	1	5
Hibiscus esulentus (pods)	1	1	1	2	1	6
Hibiscus sabdariffa	1	2	1	1	1	6
Althaea rosea	1	2	1	2	1	7
Hibiscus cannabinus (hurds)	1	1	3	1	2	8
Hibiscus esculentus	1	3	1	1	2	8
Abutilon theophrasti	2	3	2	1	1	9
Moraceae						
Cannabis sativa	1	1	1	2	1	6
Polygonaceae						
Polygonum persicaria	2	2	2	3	2	11
Umbelliferae						
Cicuta maculata	1	2	3	2	3	11
Heracleum lanatum	1	2	3	2	3	11

Leguminosae. As a whole the legumes appear promising. Of five members analyzed, three had point ratings of 8 or less. *Crotalaria juncea* appears to be especially promising and additional screening of representatives of this species is in progress. Representatives of *C. juncea* exhibited considerable variability in plantings at Peoria, Ill. A Brazilian variety grew to a height of 8 ft. while another variety reached a height of but 5 or 6 ft. The other variety flowered; the Brazilian variety continued growth until frost and did not flower. Preliminary pulping experiments with *C.* and okra have been suggested as practical substitutes for jute fiber (*33*). Additional work is in progress on selected members of this family. A number of kenaf varieties, grown in various sections of this country, are in process of evaluation.

Moraceae. The only member of this family examined was *Cannabis sativa.* This species received a point rating of 6 and shows considerable promise as a source of pulp. However, production of hemp in the United States is rigidly controlled to prevent its illegal use as marijuana. Because of this, growth for

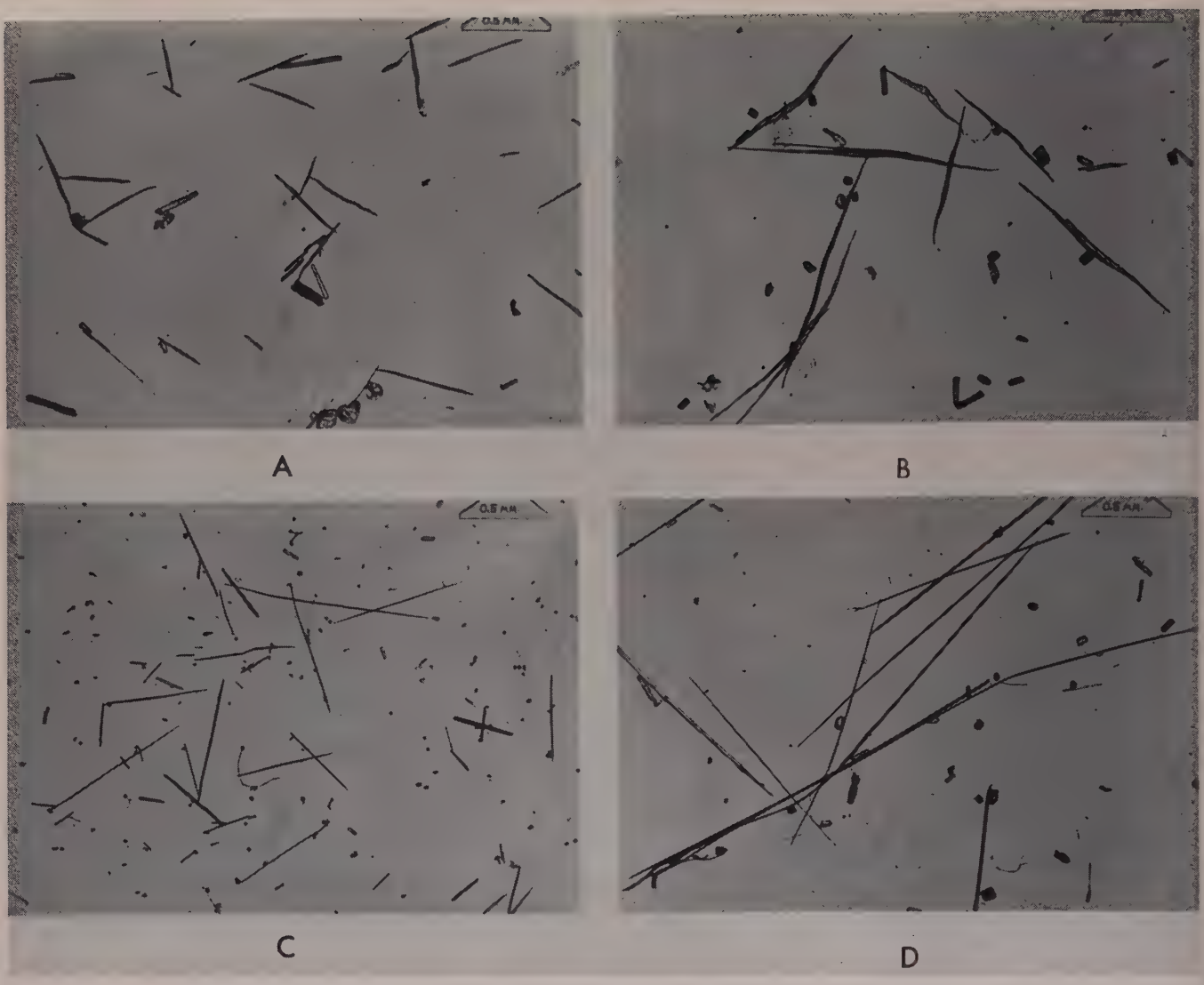


Fig. 1. Typical macerates (50×) illustrating extremes of fiber lengths encountered

Woody fibers of dicotyledons: (A) *Solidago sempervirens*, (B) *Hibiscus esculentus*. Fibers of monocotyledons: (C) *Stipa coronata*, (D) *Bambusa vulgaris*.

utilization as a source of pulp would be complicated.

Polygonaceae. Only one member of the buckwheat family, *Polygonum persicaria*, was analyzed. Although it had a low rating, it was a borderline case. Family potential cannot be judged on the basis of data from a single species.

Umbelliferae. Neither of the two members of the parsley family, *Cicuta maculata* and *Heracleum lanatum*, analyzed by our screening procedure showed promise as a potential pulping material.

SUMMARY AND CONCLUSIONS

1. A scheme has been devised for evaluation of potential fiber plants as new sources of paper pulp. This evaluation procedure involves consideration of botanical characteristics, chemical composition, yield and dimensional measurements of fibrous constituents, and a qualitative physical and visual appraisal of the plant.

2. Although the validity of this evaluation procedure can be positively established only by experimental pulping, some indications that it provides a valid appraisal are presented.

3. A total of 58 plant species representing 11 families is reported. Representatives of the *Gramineae*, *Leguminosae*, and *Malvaceae* appear to be the most promising of the limited number of samples examined.

4. Fiber screening will continue with the appraisal of numerous additional species of greater diversity within the plant kingdom.

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Alkali Sorption on Wood from Dilute Aqueous Solutions

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The sorption of alkali from dilute aqueous solutions of sodium hydroxide, alkaline sodium zincate, sodium sulfide, and from commercial kraft cooking liquor on small size wood subdivisions was studied, using particularly low alkalinities up to the range of commercial alkaline cooking liquors. Maximum sodium hydroxide sorption from sodium hydroxide-containing liquors was obtained within a few minutes without preceding de-aeration, particularly if turbulent mixing of the resulting slurry was maintained during the reaction. At low sodium hydroxide concentration, chemisorption was found to prevail. Further, a sorption plateau corresponding to a final liquor concentration between about 2 and 5% NaOH was found. By using a modified centrifuging technique, the alkali and water retentions of the treated wood samples were determined, and a nearly constant ratio was found. The alkali and water retention values of the centrifuged samples were found to be insignificantly influenced by the moisture content of the initial wood. For instance, approximately the same retention values were obtained in samples ranging from air-dry wood to that of 75% water content. The sorption phenomena which occur, if small-size wood subdivisions are reacted with alkaline sodium zincate solutions of varying alkali and zinc oxide content, were also studied. It was found that the presence of zinc oxide in the alkaline liquors increases appreciably the alkali sorption, but that the water retention increases only to a minor degree. Finally, the alkali sorption from aqueous sodium sulfide solutions and from commercial kraft cooking liquor was investigated. Sodium hydroxide formed by hydrolysis of sodium sulfide in aqueous solutions was preferentially sorbed and definite amounts of sulfur were taken up. There is evidence that the hydrosulfide ions are responsible for this sulfur sorption. From commercial kraft cooking liquor containing 27.2% effective alkali and having 25.4% sulfidity, the sulfur being present mainly as the sulfide ion, no sulfur sorption on wood was noticed.

The sorption of sodium hydroxide on wood from aqueous solutions and the concurrent water uptake resulting in swelling have a bearing on alkaline pulping reactions, particularly in the so-called cold caustic soda process. In this pulping process the wood material is soaked in dilute alkali solutions and mechanically defibrated. Both the susceptibility of the wood to defibration and the quality of the resulting pulp are influenced by the presence of alkali (*1*).

In the sorption of chemicals from aqueous solutions (*2*), and in the sorption of water vapor (*3, 4*), the various components of wood exhibit distinct differences. Various morphological structures are likewise associated with different sorption characteristics (*3*). The sorption phenomena on wood are very complex (*5*), with chemisorption, unimolecular and multimolecular sorption occurring concurrently. In a new space theory of sorption, Malmquist (*6*) recently postulated that the degree of cohesion of the wood structure is a factor in the sorption of water vapor on wood.

Alkali sorption has a bearing on the penetration (*7*) of wood chips with alkaline liquors prior to cooking. It also might have some influence on the alkali distribution, particularly at the beginning of cooking. Maass *et al.* (*8*) postulated that alkaline cooking occurs locally in the interface between the liquid phase of the cooking liquor and the solid phase of the lignin in the wood. Nolan *et al.* (*9*) consider alkaline pulping as taking place in an interface which moves into the wood during cooking. There is also some evidence that, in general, the sorption of cooking chemicals on the lignin layers of the wood is a factor in pulping (*8, 10*).

The sorption of alkali on wood and wood components has been investigated by several workers (*7, 11–13*). Various phenomena are involved because the wood is not only heterogeneous but also slightly acidic (*14, 15*). Acetyl and formyl groups present, particularly in hardwoods, are split off by the action of alkali and demand distinct amounts of alkali for neutralization. In contact with aqueous alkaline solutions, certain portions of

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the wood substance are dissolved. The data of the apparent sorption collected from the measurements of the change in concentration of the liquid phase before and after reaction must therefore be corrected for the losses of substance. Another difficulty is that the wood takes up water concurrently with the alkali. However, as can be seen from the present investigation, in the range of concentrations used, the ratio of the alkali sorbed to the water retained, under standardized conditions, is approximately constant. Therefore, the empirical sorption figures obtained in the concentration measurements can be used for comparison and give valuable information on the actual phenomena.

In investigating the alkali sorption on cellulose from concentrated sodium hydroxide solutions, Davidson (*16*) found that the presence of relatively small amounts of sodium zincate in the alkaline liquor increases the swelling and dissolving power of the alkali. Borgin and Stamm (*17*) investigated the exchange of radioactive zinc between cellulose and concentrated sodium hydroxide solutions containing sodium zincate. They found that the zinc exchange is reversible.

Of considerable interest are the alkali sorption on wood from commercial kraft cooking liquor and the sulfur uptake.

In the present investigations, the sorption at room temperature of sodium hydroxide on small-size wood subdivisions from aqueous solutions of sodium hydroxide, alkaline sodium zincate, sodium sulfide, and from commercial kraft cooking liquors was studied.

In most of the experiments, the water retention values of the treated wood materials after standardized centrifuging were determined. The alkalinity of the experimental liquors was limited to the range of alkalinity used in commercial pulping processes. Spruce sawdust, and, in a few cases, poplar wafers were used in these experiments. In particular, the sorption phenomena which occur when wood is reacted with the alkaline liquors for relatively short periods of time were studied.

EXPERIMENTAL WORK AND RESULTS

The sawdust used in the sorption studies was air-dry, and consisted of the fraction which passed through the 40-mesh screen but was retained by the 60-mesh screen. In order to simulate the conditions prevailing in commercial alkaline pulping, the resinous portions were left in the wood; i.e., the wood was used without any preceding extraction. In order to characterize the wood, the amounts of alcohol-benzene and ether extractives present were determined, as was the solubility of the wood in 5% NaOH solution at 20°C. Table I presents these solubility data. All experimental data reported in this paper are mean values of at least duplicate determinations.

Time Factor

For commercial pulping, particularly if continuous processes are considered, the time factor of the alkali sorption on wood from alkaline liquors is of special interest. This applies not only to the cold caustic soda pulping of wood chips in disk mills but also to kraft pulping. It has a special bearing on the forced penetration of alkaline liquors into wood, and this phenomenon has been studied separately (*7*).

Table I. Extractives and 5% NaOH Solubility of Spruce Sawdust

Moisture, %	4.80
Alcohol-benzene 1:2 extraction	1.07
Followed by ether extraction	0.04
Ether extraction	0.57
Followed by extraction with alcohol-benzene 1:2	0.70
5% NaOH-solubility, 20°C., 24 hr	5.30

In preliminary investigations it was found that with very short reaction time (a few minutes), maximum alkali sorption took place, but that concurrently, distinct amounts of the wood were dissolved by the alkaline liquors, liquor composition being a factor. Therefore, these material losses were determined and due corrections of the apparent sorption data were made.

The time factor of sorption for the various alkaline liquors was studied and the results obtained are presented in the three sections of this paper: sodium hydroxide solutions, alkaline zincate solutions, and sodium sulfide solutions.

Sodium Hydroxide Solutions

The apparent sodium hydroxide sorption was calculated from the changes in concentration of the alkaline solutions before and after reaction with the wood material, using the equation of Richardson and Maass (*11*). In all experiments the wood to liquor ratio was 1:20 and the temperature 20°C. The samples of the liquid phase were weighed for analysis.

Table II shows the influence of the reaction time on the NaOH-sorption of spruce sawdust from sodium hydroxide solutions of varying concentration. From the experimental data it can be seen that with a 2% NaOH solution, the apparent alkali sorption reaches a maximum within 5 min., and that at the higher alkali concentrations of the liquor (3 and 4% NaOH), the sorption maximum is attained within 3 min. reaction time. This finding is related to the dissolving of certain wood portions by the liquor and a corresponding release of sorbed alkali. At lower alkali concentration (1% NaOH), the alkali sorption and the dissolving of wood portions are both slowed down. These experiments show clearly that maximum alkali sorption on small size wood subdivisions from a sodium hydroxide solution, comparable in concentration to a commercial kraft cooking liquor, is fast and takes place in a few minutes without any preceding deaeration. Further experiments have confirmed that this also applies to the usual kraft cooking liquors.

Table II. Apparent NaOH-Sorption, %, on Spruce Sawdust from Dilute Sodium Hydroxide Solutions of Varying Concentrations with Variation of the Reaction Time

	Initial concn. 0.966% NaOH		*Initial concn. 1.993% NaOH*		*Initial concn. 3.036% NaOH*		*Initial concn. 3.918% NaOH*	
Time min.	*Final NaOH-concn., %*	*App. sorpn., % NaOH*	*Final NaOH-concn., %*	*App. sorpn., % NaOH*	*Final NaOH-concn., %*	*App. sorpn., % NaOH*	*Final NaOH-concn., %*	*App. sorpn., % NaOH*
3	0.861	2.50	1.851	3.42	2.845	4.59	3.684	5.70
5	0.854	2.69	1.839	3.71	2.850	4.47	3.696	5.39
10	0.848	2.84	...	..	...	..	3.698	5.35
20	0.839	3.09	1.840	3.69	2.850	4.48	3.70	5.31
60	0.834	3.19	1.840	3.69	2.850	4.48	3.70	5.30
120	0.829	3.29	...	..	...	..	3.70	5.30
180	0.829	3.29	1.840	3.70	2.851	4.46	3.70	5.30

These sorption data are also presented in Fig. 1.

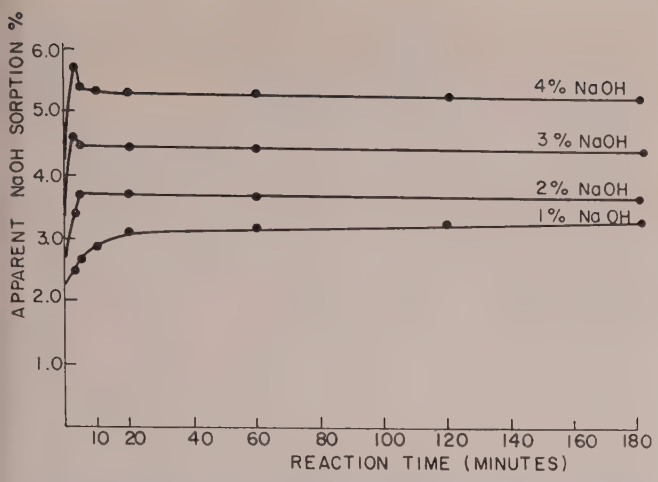

Fig. 1. Apparent NaOH sorption (%) on spruce sawdust from dilute sodium hydroxide solutions of varying concentration with variation of the reaction time

To determine the final equilibria, more experiments were performed, with reaction time extended to 24 hr. The liquid and solid phases were separated on the one hand by centrifuging under standardized conditions and on the other by filtration in a sintered glass crucible. The conditions of centrifuging used in these investigations were: 10 min. at a centrifugal accelerating force (CAF) of about 200 g. For determining the water retention (W.R.V.) of treated sawdust separated by filtration from the liquor, the sintered glass crucibles containing the samples were also centrifuged under standardized conditions. For comparison, the data obtained in these two series of experiments are presented in Tables III and IV. They indicate that the separation procedure used has a bearing on the final liquor concentration. Obviously, in centrifuging, the residual liquor adherent to the wood material is removed to a greater extent than in filtration. This liquor contains dissolved wood portions rich in sorbed alkali. By centrifuging, part of these portions is removed. Tables

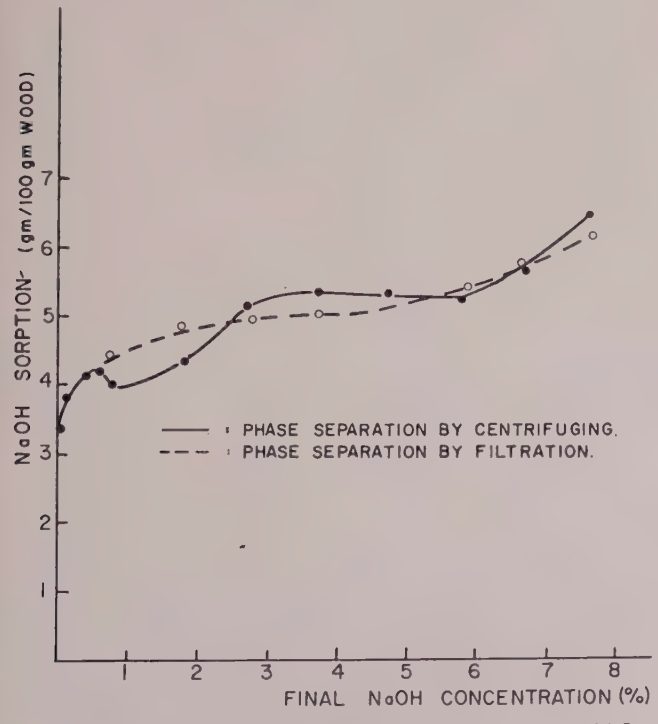

Fig. 2. Sorption from sodium hydroxide solutions; 24-hr. reaction time

Table III. Alkali Sorption and W.R.V. of Spruce Sawdust After Reacting with Dilute Sodium Hydroxide Solutions of Varying Concentrations; Reaction Time 24 Hr., Phase Separation by Centrifuging (10 Min., 200 g.)

Liquor		Solid phase after centrifuging				
				Data corrected for dissolved portions		
Initial NaOH, %	Final NaOH, %	Apparent sorption of NaOH, %	Loss of diss. subst., %	Sorption of NaOH, %	Water retention, %	Ratio NaOH : H_2O multiplied by 100
0.190	0.031	3.06	3.64	3.19	145	2.2
0.380	0.190	3.65	4.11	3.82	155	2.5
0.617	0.410	3.94	4.36	4.12	153	2.7
0.820	0.610	4.04	4.44	4.23	157	2.7
0.97	0.77	3.84	4.52	4.02	157	2.6
1.99	1.77	4.25	5.00	4.29	167	2.6
2.97	2.71	4.93	5.43	5.17	178	2.9
3.97	3.70	5.00	5.66	5.35	188	2.8
4.94	4.68	4.96	5.72	5.29	200	2.6
5.96	5.70	4.98	6.23	5.26	208	2.5
6.97	6.70	5.40	6.53	5.66	226	2.5
7.94	7.63	5.98	6.69	6.46	252	2.6

III and IV exhibit the loss of dissolved organic substances, the corrected data of the NaOH-sorption, the calculated water retention value (W.R.V.) and the ratio of sorbed sodium hydroxide to water, multiplied by 100. The alkali sorption is also presented in Fig. 2. In general, it can be seen that at low NaOH-concentration (up to about 1% NaOH), the alkali sorption rises quickly, this being due mainly to chemisorption by acidic wood components (*9, 10*). In the series in which separation of the sample from the excess liquor was achieved by filtration, a gradual increase of the alkali sorption, however slow, occurs with increasing sodium hydroxide concentration of the final liquor, whereas in the series with separation by centrifuging, a noticeable drop of the alkali sorption values in a range between about 0.8 and 2.3% NaOH of the liquor can be seen. In both series a kind of sorption plateau can be observed, corresponding to a final liquor concentration between about 2.7 and 6% NaOH. At concentrations higher than about 0.5% NaOH the ratio of sorbed alkali to W.R.V. becomes approximately constant.

For comparison with the 24 hr. sorption experiments, two series of experiments were carried out under the same conditions but with 15 min. reaction time. In these experiments, separation of the liquid and solid phases also was achieved by centrifuging (Table V) on the one hand and filtration (Table VI) on the other. The results are presented in Fig. 3. As can be seen, where sodium hydroxide concentration is low, the sorption values exhibited were appreciably lower compared with those with 24 hr. reaction time. In the alkalinity

Table IV. Alkali Sorption and W.R.V. of Spruce Sawdust after Reacting with Dilute Sodium Hydroxide Solutions of Varying Concentrations; Reaction Time 24 Hr., Phase Separation by Filtration

Liquor		Solid phase after filtration				
				Data corrected for dissolved portions		
Initial NaOH, %	Final NaOH, %	Apparent sorption of NaOH, %	Loss of diss. subst., %	Sorption of NaOH, %	Water retention, %	Ratio NaOH : H_2O multiplied by 100
0.97	0.75	4.25	4.48	4.45	155	2.9
1.98	1.74	4.60	4.88	4.84	171	2.8
2.98	2.74	4.64	5.38	4.96	186	2.7
3.97	3.72	4.80	5.65	5.09	198	2.6
4.93	4.69	4.63	5.70	4.91	193	2.5
5.91	5.65	4.01	5.64	5.31	213	2.5
6.91	6.63	5.35	6.14	5.70	232	2.5
7.96	7.66	5.77	6.66	6.18	265	2.3

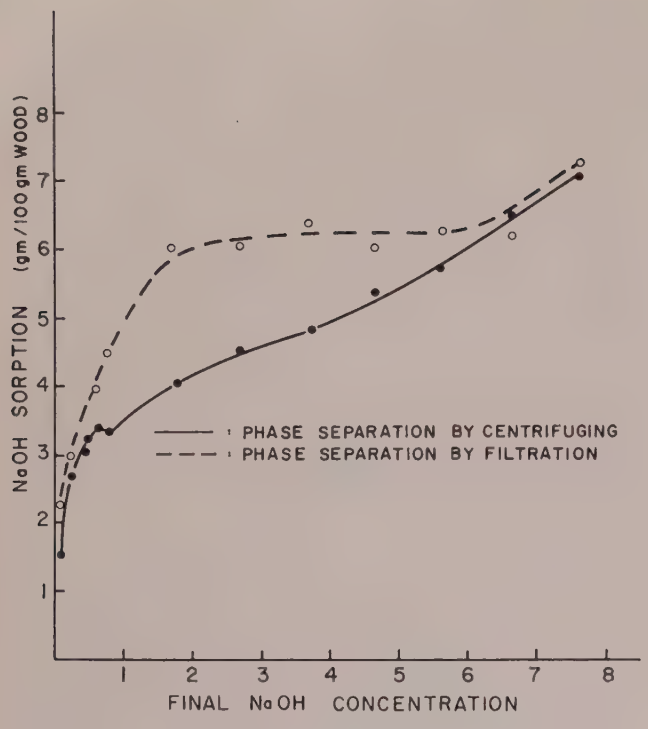
NaOH SORPTION (gm/100 gm WOOD)
FINAL NaOH CONCENTRATION
PHASE SEPARATION BY CENTRIFUGING
PHASE SEPARATION BY FILTRATION

Fig. 3. Sorption from sodium hydroxide solutions; 15-min. reaction time

range used in commercial kraft pulping, however, only minor differences were exhibited, and the W.R.V. showed little change. These findings demonstrate that if small size subdivisions of wood are used, alkali sorption and water retention, when commercial alkaline pulping liquors are used, occur quickly and to an extent which is only insignificantly lower than that of the final equilibria.

The water retention values (W.R.V.) listed in Tables III to VI were obtained from the sample weight after centrifuging (10 min., 200 g.) by deducting the weight of the insoluble wood residue (determined gravimetrically) and that of the alkali retained (A.R.V.), determined titrimetrically. All these values were expressed in per cent of the ovendry, insoluble wood residue.

In a series of investigations, Jayme *et al.* (*18, 19*) studied the water retention of pulp materials as a characteristic pulp quality. In the present investigation, a similar technique has been applied, using 10 min. centrifuging time and a centrifugal accelerating force of 200 g.

Table V. Alkali Sorption and W.R.V. of Spruce Sawdust After Reacting with Dilute Sodium Hydroxide Solutions of Varying Concentrations; Reaction Time 15 Min., Phase Separation by Centrifuging (10 Min., 200 g.)

Liquor		Solid phase after centrifuging				
				Data corrected for dissolved portions		
Initial NaOH, %	Final NaOH, %	Apparent sorption of NaOH, %	Loss of diss. subst., %	Sorption of NaOH, %	Water retention, %	Ratio NaOH:H₂O multiplied by 100
0.190	0.110	1.46	2.79	1.50	135	1.1
0.380	0.240	2.62	3.29	2.71	145	1.9
0.617	0.460	2.94	3.54	3.05	152	2.0
0.805	0.635	3.27	3.72	3.39	145	2.3
0.97	0.80	3.24	3.60	3.36	158	2.1
1.96	1.76	3.85	4.13	4.02	167	2.4
2.94	2.71	4.35	4.44	4.56	176	2.6
3.97	3.73	4.59	4.93	4.81	182	2.6
4.93	4.66	5.12	4.82	5.38	195	2.8
5.89	5.59	5.45	4.95	5.74	202	2.8
6.94	6.60	6.19	5.37	6.54	230	2.8
7.94	7.60	6.66	5.60	7.05	244	2.9

Table VI. Alkali Sorption and W.R.V. of Spruce Sawdust After Reacting with Dilute Sodium Hydroxide Solutions of Varying Concentrations; Reaction Time 15 Min., Phase Separation by Filtration

Liquor		Solid phase after filtration				
				Data corrected for dissolved portions		
Initial NaOH, %	Final NaOH, %	Apparent sorption of NaOH %	Loss of diss. subst., %	Sorption of NaOH, %	Water retention, %	Ratio NaOH:H₂O multiplied by 100
0.190	0.073	2.25	2.79	2.31	135	1.7
0.380	0.229	2.88	3.28	2.98	145	2.1
0.617	0.455	3.13	3.54	3.24	152	2.1
0.820	0.620	3.84	3.73	3.99	146	2.7
0.98	0.75	4.37	3.31	4.51	150	3.0
1.98	1.68	5.79	3.64	6.01	167	3.6
2.98	2.68	5.77	3.97	6.01	172	3.5
3.98	3.66	6.10	4.46	6.38	182	3.5
4.92	4.62	5.74	4.69	6.02	196	3.1
5.91	5.60	5.96	4.96	6.27	209	3.0
6.91	6.61	5.89	5.38	6.23	239	2.6
7.96	7.60	6.90	5.70	7.31	251	2.9

Determination of the sorption of sodium hydroxide from dilute solutions, similar to that described for spruce sawdust, was also carried out with poplar wafers of about 0.3 mm. thickness. The wafers were soaked 5 min. in dilute sodium hydroxide solution (wood to liquor ratio 1:20) and then the mixture was defibrized for 90 sec. in a Waring Blendor. After 5 min. retention time of the resulting slurry, the fiber mass contained in a fine wire mesh basket was separated from the excess liquor by centrifuging (10 min., 200 g.). The total retention value (T.R.V.) was determined and also the retention value of the alkali (A.R.V.). The water retention value (W.R.V.) was calculated by difference.

To study the effect of initial wood moisture on retention values, experiments were conducted with poplar wafers of increasing moisture content. Wafers of freshly cut wood of about 45% moisture content were used as initial material in these experiments. To obtain samples of lower moisture content the wood was partially air dried at room temperature. For higher moisture contents, the wafers were moistened to a varying degree and then conditioned in polyethylene bags. The results of these investigations are presented in Table VII.

Table VII. Retention Values of Poplar Wood of Increasing Moisture Content Defibrized in Presence of Aqueous 4% NaOH Solution

Initial wood moisture, %	Retention values expressed in % of the insoluble wood residue		
	T.R.V.	A.R.V.	W.R.V.
7.5	253	12.2	241
23.9	266	12.7	254
44.6	252	12.2	240
59.2	270	13.1	257
70.6	270	13.1	257
74.6	276	13.3	263

Table VII shows that the values of the alkali and water retention of the treated and centrifuged wood material are quite similar. In other words, the wood moisture seems to be no major factor. It is noticeable that the retention values of the fibrous mass produced from wood of higher moisture content compared with those from low-moisture, air-dry samples are a little

higher. This finding indicates that the greater swelling of the wood of higher initial moisture is responsible for the increased retention values. However, in practice, the deviations of retention values caused by variation of the initial moisture content of the wood are small. In general, findings show that in spite of the short time of interaction during the turbulent defibration of the wood, an exchange of wood moisture and liquor must have taken place. This was determined from the retention data of the samples of high initial water content. Since, within the short time of interaction, diffusion could not have played a major role, it appears that a mechanical phenomenon related to the turbulent mixing but as yet not elucidated might have been responsible for the fast exchange.

In connection with cold caustic soda pulping, for instance, these results demonstrate that wood of varying moisture content, if subjected to mechanical defibrizing in presence of the alkaline pulping liquor, is transformed into a fibrous mass which after centrifuging retains about the same amounts of alkali and water irrespective of the initial wood moisture, exhibiting a calculated ratio of insoluble wood residue to liquor of about 1:2.5 to 2.8.

In some centrifuging experiments, the influence of the centrifugal accelerating force CAF (100 g. and 200 g.) on the total retention (T.R.V.) with variation of the centrifuging time was determined.

Air-dry poplar wafers (0.3 mm. thick, 7.8% moisture) were soaked in an excess of 4 and 5% NaOH solution, respectively (ratio 1:20), and briefly (90 sec.) defibrized in a Waring Blendor. The fiber mass was separated from the liquor by filtering in a fine wire-mesh basket, which was also used for the subsequent centrifuging. The total retention (T.R.V.) and the alkali retention (A.R.V.) were determined. The experimental results are presented in Table VIII.

Table VIII. Influence of CAF and Time on the Retention Values (T.R.V.; A.R.V.)

NaOH, %	*CAF, g.*	*T.R.V.; A.R.V.*	*Time of centrifuging*			
			30 sec.	*60 sec.*	*300 sec.*	*600 sec.*
4% NaOH	100	T.R.V.	401%	378%	344%	335%
	100	A.R.V.	18.1%	17.2%	16.0%	15.7%
	200	T.R.V.	320%	315%	279%	253%
	200	A.R.V.	14.9%	14.7%	13.2%	12.2%
5% NaOH	100	T.R.V.	410%	401%	348%	341%
	100	A.R.V.	22.2%	22.0%	19.6%	19.5%
	200	T.R.V.	326%	312%	280%	266%
	200	A.R.V.	18.8%	18.1%	16.8%	16.1%

Centrifuging with 200 g. was found to be more practical than that with 100 g., because of a faster levelling-off of the retention values. Centrifuging with 200 g. and a centrifuging time of 10 min. was finally adopted for determination of the retention values.

Alkaline Zincate Solutions

The alkali sorption and water retention of wood in cold or at slightly-elevated temperatures is of technical interest in particular when cold caustic soda defibration of wood chips in disk mills is considered. The presence of alkali, resulting in a greater swelling of the wood, makes the defibration process easier and decreases fiber damage. To find out if the addition of sodium zincate to alkaline liquors caused an increase in wood swelling, measured by water retention, studies were

Table IX. Time Influence on the Sorption of Alkaline Sodium Zincate Solutions on Spruce Sawdust; Initial Liquor; (A) 3.998% NaOH + 0.481% ZnO; (B) 4.103% NaOH + 0.970% ZnO

Reac. time, min.	*Liquid phase*		*Solid phase*			
			Apparent sorption		*Sorption calcn. on oven-dry residual wood*	
	NaOH, %	*ZnO, %*	*NaOH, %*	*ZnO, %*	*NaOH, %*	*ZnO, %*
			(A)			
3	3.769	0.460	5.55	0.51	5.83	0.53
5	3.778	0.463	5.33	0.43	5.60	0.45
10	3.776	0.468	5.38	0.32	5.65	0.33
20	3.776	0.470	5.38	0.27	5.65	0.28
180	3.772	0.470	5.47	0.27	5.75	0.28
			(B)			
3	3.868	0.937	5.69	0.80	5.98	0.84
5	3.833	0.942	6.54	0.68	6.88	0.71
10	3.836	0.945	6.47	0.61	6.80	0.64
20	3.836	0.943	6.47	0.65	6.80	0.69
180	3.833	0.944	6.54	0.63	6.88	0.66

The sorption data are also presented in Fig. 4.

conducted with liquors containing 4 and 8% NaOH and varying amounts of zinc oxide. Spruce sawdust and poplar wafers mechanically defibrated in presence of alkaline liquor were used in these experiments. Defibration of the wafers was achieved by use of a Waring Blendor.

To determine the sodium hydroxide content of the alkaline sodium zincate solutions, an excess of $N/2$ (or $N/10$) H_2SO_4 was added to the weighed sample and the residual acid was back-titrated with $N/2$ (or $N/10$) NaOH solution in presence of phenolphthalein until the appearance of a permanent pink color. The zinc was determined by precipitation with ammonium phosphate. Before precipitation, the solutions were slightly acidified with hydrochloric acid, and then ammonium chloride, ammonium acetate and a small amount of ammonium hydroxide were added. During the precipitation of the zinc the pH of the solution was kept at 6.9 to 7.2 and controlled by a Beckman G pH meter.

A series of experiments were carried out to determine the influence of the reaction time on the apparent sorption of alkali and zinc on spruce sawdust from alkaline sodium zincate solutions. The solutions were chosen so as to contain about 4% NaOH, and 0.5 and 1% ZnO,

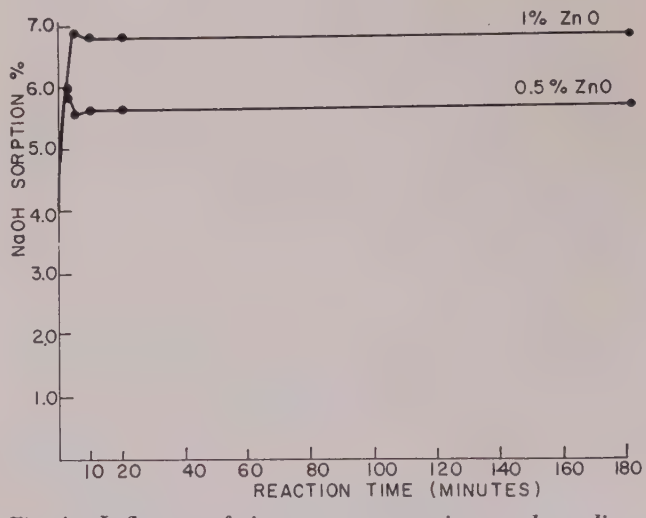

Fig. 4. Influence of zincate concentration on the sodium hydroxide sorption on spruce sawdust from alkaline zincate solutions of 4% NaOH content; variation of reaction time

respectively. The moisture content of the wood was 17.6%. A wood to liquor ratio of 1:20 was used, and the reaction temperature was 20°C. The figures for the apparent sorption and those corrected for the dissolved portions are listed in Table IX.

Table X. Sorption of Alkaline Sodium Zincate Solutions of Varying Concentration on Spruce Sawdust, Determined by the Changes of the Liquor Concentration; Reaction Time 20 Min.

Initial liquor		Final Liquor		Sorption on solid phase					
				Apparent sorption		Corrected		Mole-ratio,	W.R.V. of centrifuged sample, %
NaOH, %	ZnO, %	NaOH, %	ZnO, %	NaOH, %	ZnO, %	NaOH, %	ZnO, %	NaOH:ZnO	
3.970	...	3.730	...	4.59	..	4.81	..	..	182
3.998[a]	0.481	3.776	0.470	5.39	0.26	5.65	0.28	42:1	204
4.103[a]	0.970	3.836	0.943	6.47	0.65	6.80	0.69	20:1	224
7.940	...	7.600	...	6.66	..	7.05	..	..	244
8.189[a]	1.000	7.836	0.987	8.55	0.31	9.03	0.33	56:1	256
8.120	1.960	7.570	1.926	10.29	0.63	10.88	0.68	33:1	269

[a] The moisture content of these wood samples was 17.6%, that of the others 4.8%.

It can be seen that maximum sorption takes place in a few minutes. In the ensuing experiments a reaction time of 20 min. was used. Table X presents a few sorption data obtained with alkaline sodium zincate solutions of varying concentrations. In addition, the water retention values of the same samples after centrifuging (10 min. 200 g.) were determined (Table X, last column). It can be seen that the W.R.V. is only slightly increased by increase of the zincate concentration, whereas the alkali sorption is appreciably higher.

Of interest are the ratios of the sorption of sodium hydroxide and zinc oxide expressed in molecular units. It can be seen that they are greatly influenced by the alkali as well as the zincate concentration. In Table XI a few data of the solubility of spruce sawdust in alkaline zincate solutions are given.

Of special technical interest was a study of the behavior of wood wafers (poplar) in alkaline zincate solutions and the influence of soaking time and mechanical defibrating on the final weight of the sample after centrifuging and on its alkali and water content. A series of experiments were carried out in which the wafers (moisture content 31.4%) were submerged and soaked in an alkaline sodium zincate solution of 4% NaOH and 1% ZnO content (wood to liquor 1:20) with variation of the soaking time; subsequently the mixture was mechanically defibrized in a Waring Blendor for 90 sec. After each stage of treatment the wood was centrifuged (10 min., 200 g.). The final weights of the samples were determined and the difference with the initial ovendry wood expressed in per cent of the ovendry residue. The results are listed in Table XII.

The results show that most of the weight increase during soaking takes place within the first 10 min., and that brief mechanical defibrizing of the wafers in the mixture greatly increases the total retention. This finding seems to be related not only to the resulting increase of surface during defibrizing but also to the mechanical phenomenon of the high-speed chemical exchange in the turbulent heterogeneous system mentioned above. In another series of experiments, soaking of the wafers (31.4% moisture content) for 5 and 20 min., respectively, was studied with and without subsequent 90 sec. mechanical defibrizing in the Waring Blendor. Soaking in water alone, in 4% NaOH solution, and in alkaline sodium zincate solution containing 4% NaOH plus 1% ZnO was compared. For determining the final weights, the samples were centrifuged (10 min., 200 g.). The results are presented in Table XIII.

From Table XIII it can be seen that:

(1) At varied soaking time, and with and without mechanical defibrizing respectively, soaking of the wafers in both of the alkaline liquors compared with soaking in water alone results in higher final sample weights.

(2) When 5 min. soaking of the wood in 4% NaOH and in 4% NaOH plus 1% ZnO solution, with and without mechanical defibrizing are compared, the final sample weights exhibit only minor differences; with 20 min. soaking time, however, the values obtained with the alkaline zincate solution are appreciably higher.

(3) In all cases investigated, mechanical defibrizing of the wood in presence of liquor results in a considerable weight increase.

The water retention and the sorption of the chemicals by wood from an alkaline sodium zincate solution (4% NaOH plus 1% ZnO) with concurrent mechanical treatment was studied separately. Spruce sawdust and poplar wafers, both produced from seasoned wood of about 5% moisture content, were used in these ex-

Table XI. Solubility of Spruce Sawdust in Alkaline Sodium Zincate Solutions of Varying Concentration; Reaction Time 180 Min.

Initial liquor		Weight loss of the wood, %
NaOH, %	ZnO, %	
4.00	..	4.96
4.01	0.48	4.90
3.94	0.93	4.80
8.19	1.00	5.32
8.17	1.93	6.13

Table XII.

Soaking time, min.	Total retention (T.R.V.) oven-dry wood	
	After soaking	After soaking and mechanical disintegration
5	148	192
10	149	209
15	154	207
20	162	208
30	152	204
60	151	209
120	152	223
180	151	214

Table XIII. Weight Increase of Poplar Wafers by Soaking in Various Liquors With and Without Subsequent Mechanical Defibrizing

Treatment of a 10 g. air-dry sample	Final weight (g.) of the centrifuged sample[a] Water	4% NaOH soln.	Soln. in 4% NaOH + 1% ZnO
5-min. soaking, centrifuging	12.96 (88.9%)	17.03 (148.2%)	17.02 (148.1%)
5-min. soaking, mech. defibrizing (90 sec.) plus centrifuging	14.86 (116.6%)	20.00 (191.5%)	20.04 (192.1%)
20-min. soaking, centrifuging	13.60 (98.2%)	17.13 (149.7%)	17.99 (162.2%)
20-min. soaking, mech. defibrizing (90 sec.) plus centrifuging	16.04 (133.8%)	19.90 (190.0%)	21.16 (208.4%)

[a] Values in parentheses: Final weight minus wood, calcd. in % of oven-dry wood.

periments. The wood was soaked for 5 min. at 20°C. in the liquor (ratio 1:20), and subsequently defibrized for 90 sec. in the Waring Blendor. After a retention time of 5 min., the slurry was centrifuged in a fine wire-mesh basket for 10 min. and 200 g. The composition of the initial and the final liquor was compared and also

Table XIV. Water and Chemical Retention of Spruce Sawdust and Poplar Wafers Treated in Alkaline Sodium Zincate Solution (4% NaOH Plus 1% ZnO) with Mechanical Defibrizing of the Wood

Wood	Initial liquor NaOH, %	Initial liquor ZnO, %	Final liquor NaOH, %	Final liquor ZnO, %	Final sample after centrifuging, % of oven-dry residual wood T.R.V.	NaOH	ZnO	W.T.R.	Mole-ratio, NaOH:ZnO
Poplar wafers	3.95	0.958	3.62	0.838	217.5	11.5	2.5	203.5	9.3:1
	3.86	0.950	3.54	0.841	224.3	11.5	2.6	210.2	8.9:1
	3.87	0.950	3.55	0.840	220.3	11.8	2.9	205.6	8.3:1
Spruce sawdust	4.12	0.981	3.74	0.926	224.0	13.1	2.5	209.3	10.6:1
	4.12	0.981	3.72	0.926	254.4	12.8	2.6	239.6	10.0:1

the final weight of the sample and its composition was determined. The results are listed in Table XIV. The data of the centrifuged sample, corrected for the portions dissolved during treatment, are shown in the last 5 columns of the table. The higher sorption values obtained with the sawdust may have been caused by liquor retained in the pores of the sintered filter plate.

Table XV. Alkali and Sulfur Sorption on Spruce Sawdust from Aqueous 1% Na_2S-Solution with Variation of the Reaction Time

Reaction time, min.	Initial liquor NaOH, %	Initial liquor S, %	Final liquor NaOH, %	Final liquor S, %	Apparent sorption on wood NaOH, %	S, %	Mole-ratio NaOH:S
3	0.991	0.410	0.942	0.401	0.94	0.17	4.4:1
5	0.991	0.410	0.916	0.400	1.48	0.20	5.9:1
10	0.991	0.410	0.885	0.400	2.05	0.22	7.2:1
20	0.991	0.410	0.871	0.398	2.36	0.26	7.2:1
30	0.991	0.410	0.867	0.396	2.41	0.27	7.2:1

Sodium Sulfide Solutions

In kraft pulping, the wood material is penetrated and cooked with liquors containing sodium hydroxide and certain amounts of sodium sulfide (sulfidity). At a low alkalinity, most of the sulfur is considered to be present as the hydrosulfide ion (*20*). This can be concluded from the second dissociation constant (*21*, *22*) of hydrogen sulfide, which in particular was determined by Konopik and Leberl (*22*) using colorimetric pH measurement of sodium sulfide solutions of varying concentration.

In the present investigations, the sorption phenomena which occur when spruce sawdust is reacted at room temperature (20°C.) with either dilute sodium sulfide solutions or a pure liquor similar in composition to a commercial kraft cooking liquor were studied. In aqueous solutions, sodium sulfide is to a great extent dissociated with formation of hydroxyl ions and hydrosulfide ions. It was therefore of interest to study separately the sorption of alkali and sulfur on wood from pure aqueous sodium sulfide solutions. In order to avoid interference from atmospheric oxygen, all experiments were carried out under nitrogen with complete exclusion of oxygen.

This series of experiments was carried out at 20°C. and in a wood to liquor ratio of 1:20. The alkalinity of the liquors was determined acidimetrically; their sulfur content iodometrically. In addition, the pH of the solutions was measured by a Beckman G pH meter.

Two series of experiments were carried out, one using a 1% Na_2S solution with variation of the reaction time (Table XV), and the other using a constant reaction time of 20 min. with variation of the liquor concentration (Table XVI). The sorption data were determined by comparing the liquor composition before and after reaction. For comparison, the sorption data were expressed in molecular (NaOH) and atom (S) units, respectively. Tables XV and XVI (and Figs. 5 and 6) show that from aqueous sodium sulfide solutions far more alkali than sulfur is sorbed. There is, therefore, a preferential sorption of the alkali formed by hydrolysis of the sodium sulfide while the hydrosulfide concurrently formed is only slightly adsorbed. Further, when comparing the alkali sorption with that from pure sodium hydroxide solutions of similar concentration, it

Table XVI. Alkali and Sulfur Sorption on Spruce Sawdust from Dilute Aqueous Na_2S-Solutions with Variation of the Concentration; Reaction Time 20 Min.

Na_2S, %	Initial liquor Molarity	pH	NaOH, %	S, %	Final liquor pH	NaOH, %	S, %	Apparent sorption on wood NaOH, %	S, %	Loss of dissolved substances, %	Sorption corr. for diss. portions NaOH, %	S, %	Mole-ratio, NaOH:S
0.17	0.021	11.85	0.167	0.080	11.54	0.128	0.080	0.73	...	..	..	...	...
0.5	0.064	11.88	0.500	0.208	11.78	0.400	0.199	1.72	0.185	2.01	1.75	0.183	7.6:1
1.0	0.128	11.92	0.991	0.408	11.86	0.873	0.395	2.40	0.260	2.38	2.45	0.266	7.4:1
1.5	0.192	11.91	1.487	0.622	11.87	1.332	0.604	3.20	0.371	2.49	3.28	0.379	7.0:1
2.0	0.256	11.91	1.967	0.781	11.86	1.805	0.761	3.30	0.420	2.78	3.39	0.431	6.3:1
3.0	0.384	11.91	2.917	1.127	11.85	2.751	1.104	3.39	0.440	2.92	3.49	0.453	6.2:1

Table XVII. Alkali and Sulfur Sorption on Spruce Sawdust from Kraft Cooking Liquor (About 3% NaOH Plus 1% Na_2S) with Variation of the Reaction Time

Reaction time, min.	Initial liquor NaOH, %	Initial liquor S, %	Final liquor NaOH, %	Final liquor S, %	Apparent sorption on wood NaOH, %	Apparent sorption on wood S, %	Loss of diss. substances, %	Sorption of NaOH, %, corr. for diss. portions
5	3.946	0.388	3.734	0.388	4.42	..	..	..
10	3.946	0.388	3.735	0.388	4.42	..	..	..
20	3.946	0.388	3.723	0.388	4.67	..	3.62	4.84
30	3.946	0.388	3.720	0.388	4.74	..	..	..
60	3.946	0.388	3.722	0.388	4.64	..	..	..
180	3.946	0.388	3.723	0.388	4.64	..	3.92	4.82

is seen that the maximum sorption is slightly delayed. This indicates that the sorption phenomena are interrelated with the hydrolysis reaction. They are also influenced by the rather low concentration used in some of the experiments. With 20 min. reaction time, the

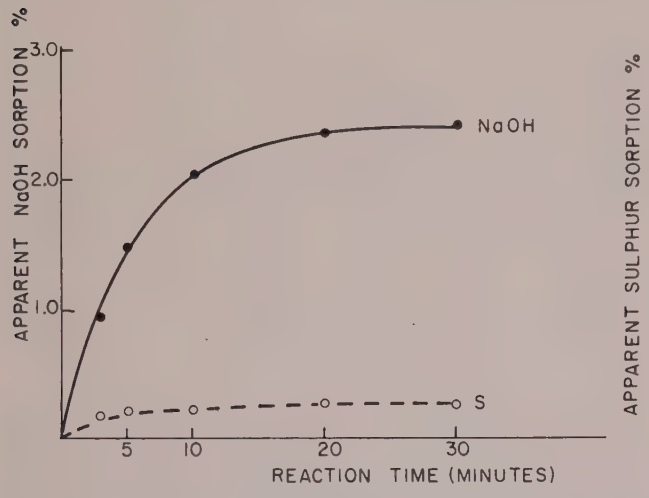

Fig. 5. Alkali and sulfur sorption on spruce sawdust from 1% sodium sulfide solution with variation of the reaction time

sodium sulfide concentration was found to be of no major influence on the ratio of the sorbed alkali and sulfur.

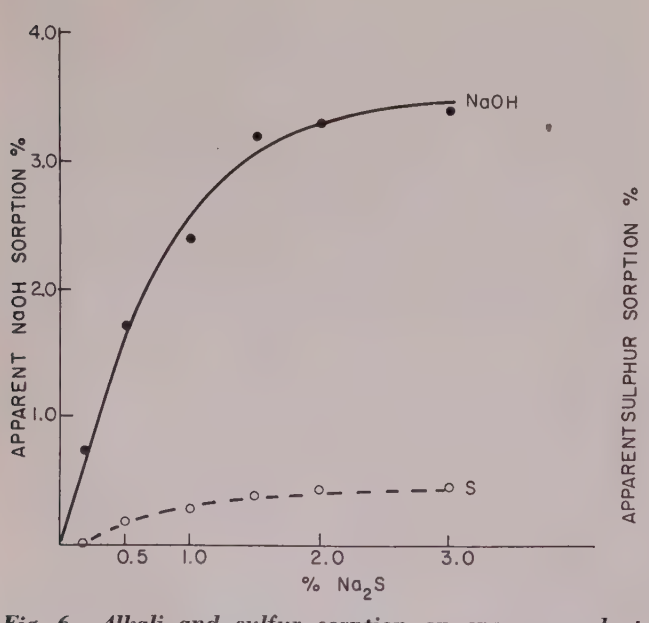

Fig. 6. Alkali and sulfur sorption on spruce sawdust from dilute sodium sulfide solutions with variation of the concentration

Interestingly, when the sorption of kraft cooking liquor (about 3% NaOH plus 1% Na_2S) with variation of the reaction time (Table XVII) was studied, no sulfur was found to be sorbed. Obviously, the sulfide ion prevailing in usual commercial kraft cooking liquor does not noticeably undergo sorption on the wood at room temperature. This also indicates that hydrosulfide ions are mainly responsible for the sulfur sorption on wood from straight sodium sulfide solutions.

When the alkali sorption on wood from alkaline kraft cooking liquors was compared with that from pure sodium hydroxide solutions of the same alkalinity, the sorption was noticeably smaller. Since temperature is no major factor in alkali sorption on wood (*23*), similar phenomena will occur during commercial kraft pulping, and the action of the alkali on the cellulose will be milder than in straight caustic soda cooking (*20*).

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Sorption Studies of a Modified Locust Bean Gum on a Bleached Sulfite Pulp

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As a contribution to better understanding of the behavior of beater adhesives, the rate of sorption of a partially methylated locust bean gum (PMG) on a bleached sulfite pulp was intensively studied. In singling out the rate-determining factors, "infinite bath" sorption conditions were approximated; gum retentions were determined directly by use of a radiochemical tagging technique. Experiments were conducted to investigate the effect on the rate of PMG sorption of the variables time, PMG concentration, temperature, degree of agitation, and pulp specific surface area. The observed experimental results demonstrated that the major rate-controlling factor in the over-all sorption phenomenon was a diffusional transport step bringing the gum molecules from the bulk phase of the solution to the surface of the fibers.

Beater adhesives are often employed to produce certain desirable characteristics in the manufacture of various grades of paper and paperboard. Many of these materials enhance fiber-to-fiber bonding, and notable strength improvements may be obtained without the great expenditure of power in refining. Where these materials are used, excessive mechanical damage to the fibers is thus obviated, and in addition to improvements in strength, papers can be made which have higher porosity, higher opacity, better formation, and with better compressibility for printing. Furthermore, with such strength improvements, higher percentages of poorer quality pulps may be used.

While certain beater adhesives work well in the laboratory, mill trials on these same materials often produce erratic results. A number of factors may be responsible for this behavior. Among these, Swanson (*1*) has mentioned the recirculation of white water for extended periods of time, and the accumulation of fines and fillers. In such mixed systems, a sorption competition may exist among the various components for the added beater adhesive. Where the major portion of the adhesive is sorbed on the fillers and fines present, the effectiveness of the adhesive may be reduced because of poor location in the sheet, satisfaction of the sorption forces of the adhesive, or poor residual adhesion. Knowledge of the basic phenomena involved in the sorption of beater adhesives is needed to better realize their capabilities.

This study was undertaken as a contribution to our understanding of the sorption behavior of polysaccharide beater adhesives. Particular emphasis was placed on the rate aspects of the problem in an effort to characterize the mechanism of the sorption process.

HISTORICAL REVIEW

Fundamental studies of the sorption behavior of polysaccharide beater adhesives have been limited, primarily because of the difficulty in accurately measuring the retention of these materials.

Some preliminary work has been done on guar and locust bean gum by Webb, Morse, and Swanson (*2*), who employed an anthrone colorimetric technique. The initial sorption of locust bean gum was found to be rapid, reaching an apparent equilibrium in about 30 min. Temperature did not seem to affect the sorption. Handsheets made at 4° and 70°C., with the same amounts of locust bean gum added, had the same bursting strength. No detectable gum was found from a sorbed pulp sample subjected to Soxhlet extraction with distilled water for 48 hr.

A further indication of the irreversibility of locust bean gum sorption is noted from the work of Leech (*3*). In this work, the washing of handsheets made from pulp to which 5% gum had been added did not alter their strength properties relative to comparable unwashed sheets.

Gruenhut (*4*), using the differential viscosity method of Shriver, *et al.* (*5*), reported that the rate of sorption of locust bean gum is dependent on solution concentration and concluded from this that the sorption takes place on the surface of the fiber. She noted that sorption decreased significantly with dilution of the gum-pulp slurry and also reported that the strength of handsheets made at 4.2°C. was greater than the strength of those made at usual (higher) temperatures. From this indirect evidence, Gruenhut concluded that gum sorption increased as temperature decreased.

An indirect colorimetric technique was also used by Keen and Opie (*6*) in their study of the sorption of guar gum on boxboard and bleached kraft pulps. Sorption appeared to take place quickly with but minor changes observed in the guar sorbed after 5 min., regardless of guar concentration. Gum sorption was only slightly dependent on gum concentration with a definite limit to the quanity of guar which could be sorbed. The authors suggest that a level of saturation exists which is perhaps dependent upon pulp specific surface area. As the degree of beating was increased, the amount of guar sorbed by both the boxboard and kraft pulps increased. An accurate determination of the effect of temperature on sorption was not made.

The sorption of polysaccharides other than mannogalactans on pulp fibers has also been reported. Shriver (*7*) studied the sorption of water-soluble cellulose ethers and found the sorption rate to be a function of the initial adhesive concentration. Sorption was found to increase three to four times from unbeaten to well-beaten pulps, and required 100 to 180 hr. for completion. With increasing temperature, sorption was found to increase, and Shriver concluded that the retention

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mechanism involved a combination of gelation and true adsorption.

Pearl (*8*) has studied the sorption and rate of sorption of the amylose fraction of starch by papermaking fibers. This system was characterized by an initially high rate of sorption, which gradually decreased with time. Sorption continued until *all the amylose in solution had been sorbed.* Complete exhaustion of the amylose in solution required times up to 600 hr. at 25°C. Sorption was irreversible with respect to concentration, and the amylose was only partially removed by an increase in temperature. The mechanism of sorption was explained as a consecutive rate process, in which the amylose was sorbed by the cellulose surface, and this amylose sorbed additional amylose.

More recently, Most (*9*) has studied the sorption of four slash pine hemicellulose fractions on a bleached sulfite pulp. During the initial period of sorption, the rate was relatively rapid. The sorption rate decreased markedly after about 10 hr., with the sorption continuing slowly at an almost constant rate, without reaching equilibrium in 10 days. Sorption was found to be irreversible with respect to concentration over a wide range of sorption levels. Most suggested a multilayer retention mechanism involving hydrogen bonding.

APPROACH TO THE PROBLEM

Analysis of data from previous sorption studies is complicated by the fact that the concentration of sorbate varied markedly during the course of the sorption experiments. In the present work, it was believed that the sorption mechanism could be better evaluated by eliminating this concentration effect by use of a so-called "infinite bath" technique. In this experimental method, a vast excess of polysaccharide in solution is employed, far in excess of the amount which could be taken up by the pulp. This approach necessitates a direct means of retention analysis.

It was decided to obtain a direct measurement of the amount of sorbed gum by means of a radiochemical tagging technique. To this end, purified locust bean gum was labeled by partial methylation with carbon^{14} methyl iodide. It is the sorption of this partially methylated gum (PMG) which is the subject of these investigations.

The over-all PMG sorption phenomenon may be considered as a complex heterogeneous process. As such, the removal of PMG from solution might be thought of as taking place in a series of steps. One or more of these may be involved as rate determining in an analysis of the over-all process. Knowledge of the factor or factors involved should do much to elucidate the basic nature of the sorption phenomenon. In the PMG-pulp system, the following steps might be considered:

1. Diffusion or transport of PMG from the bulk of the solution to the surface of the fiber.
2. PMG adsorption at the fiber surface.
3. PMG diffusion into the fiber.
4. The reverse of Steps 1 through 3.

In this research, Step 4 was obviated by concentrating on the initial rate of sorption of PMG. Similarly, diffusion into the fiber (Step 3), while possible, is not believed to occur to any appreciable degree because of the relative size of the gum polymer and that of the pores and interstices present in the pulp fibers (*10, 11*).

Table I. Pulp Properties Summarized

	Refining time, min.			
	20	35	50	75
Classified yield, after removal of fines, %	86.8	81.1	79.5	71.0
Schopper-Riegler freeness, ml.				
Unclassified	810	700	525	350
Hydrodynamic specific surface, sq. cm./g.				
Classified	9,260	11,780	15,610	29,900
Unclassified	15,300	24,000	46,000	73,900
Wet-fiber specific volume, cu. cm./g.				
Classified	2.39	2.45	2.57	2.80
Unclassified	2.58	2.78	2.60	2.77

This research, therefore, reduced itself to a consideration of a diffusional transport process (Step 1) and of adsorption proper on the fiber surface (Step 2). Either or both of these processes might have been involved as rate determining in the over-all sorption phenomenon. It was believed that an understanding of this system could best be approached by consideration of a number of experimental observations. The effect of the variables time, PMG concentration, temperature, degree of agitation, and pulp specific surface area on the rate of PMG sorption was investigated.

PREPARATION OF MATERIALS

The two primary materials for this study were purified locust bean gum (LBG) and a Weyerhaeuser standard bleached sulfite pulp.

Purification of Locust Bean Gum

The LBG for this investigation was purified from a commercial crude product according to a procedure described by Leech (*3*). In essence, this method involved the solution of the impure gum in hot water, centrifugation to remove undissolved constituents, precipitation of the gum into alcohol, and drying by solvent exchange.

Preparation and Analysis of Pulp

For the sorption studies, a series of beaten pulps were prepared. The bleached pulp was beaten in a laboratory Valley beater for intervals of 20, 35, 50, and 75 min., and then classified to remove fines and fiber debris. A Bauer-McNett classifier with 8, 16, 65, and 150-mesh screens was used for the removal of fines. The classified pulp yields are presented in Table I.

A portion of the original unclassified pulp at each beating interval was retained for analysis. The pulps were dewatered, placed in double polyethylene bags, and stored at 5°C., with 1% formaldehyde as a preservative.

For both the classified and unclassified pulps, the fiber properties of hydrodynamic specific surface area and swollen specific volume were determined by the constant rate filtration technique of Ingmanson (*12*). The results are given in Table I.

PMG SORPTION MEASUREMENTS

Principle of Method

In the past, studies of the sorptive behavior of polysaccharide beater adhesives have been difficult because of the lack of a reliable and rapid method for determining the extent of sorption. By introducing radioactive

carbon[14] into the LBG molecule, as was accomplished by Swanson, Becher, and Dickey (*13*), the sorption of gum on pulp samples may be determined by a measurement of the radioactivity present. In using this technique, the radioactive or labeled gum is not used singly, but is diluted with unlabeled gum to a known level of specific activity. This conserves the quantity of radioactive material and facilitates handling, but may introduce the complicating factor of selective sorption.

In this research, tagging of the LBG molecule was accomplished by methylation with carbon[14] methyl iodide. To eliminate problems of selective sorption, the diluent gum was partially methylated with nonradioactive methyl iodide to the same degree as in the labeling reaction.

The Manometric Determination of Carbon and Its Radioactivity

To obviate the difficulties of low efficiency counting in the solid state, it is convenient to determine the radioactivity of the sorbed PMG in the gaseous phase using the Bernstein-Ballentine (*14*) proportional counting system. The solid pulp samples were converted to gaseous products by the wet-combustion technique of Van Slyke and Folch (*15*) as modified for use with radioactive carbon samples by Van Slyke, Steele, and Plazin (*16*). Essentially, the method involves the chemical oxidation of the pulp sample completely to carbon dioxide, absorbing the gases in alkaline hydrazine solution, separating the carbon dioxide from the other liberated gases, collecting it in a proportional counting tube, diluting with methane, and counting the radioactivity present. The use of the Van Slyke combustion is especially convenient in that it permits one to determine the sorption per unit weight of pulp without the need for a separate measurement of sample size. The sample size used in the analysis is calculated from a manometric determination of the total evolved carbon dioxide prior to transferring the gas to the proportional counting tube. Details of this calculation are given in Appendix I.

Labeling LBG With Carbon[14]

Successful labeling of LBG with carbon[14] was accomplished by partial methylation with radioactive methyl iodide as suggested by Swanson, Becher, and Dickey (*13*). The sodium alcoholate of LBG was first prepared according to the technique of Gaver (*17*), and then refluxed 8 hr. with carbon[14] methyl iodide. Four labeled products were prepared containing various levels of radioactivity. These were purified by dissolving in distilled water and then recovered by precipitating into absolute alcohol. Finally, the labeled gums were dried *in vacuo*, over magnesium perchlorate, at 55°C. The average methoxyl content was 6%.

Preparation of PMG Stock Solutions

For the sorption experiments, stock solutions of PMG were prepared containing blends of radioactive material. The amount of radioactive gum present represented 10 to 20% of the total. The dry materials were weighed on an analytical balance, mixed together, and then dispersed in distilled water. Any stray material or undispersed gum particles were removed by filtering through a plug of glass wool. Two-milliliter aliquots of the stock solution were pipetted into combustion tubes for analysis of the PMG concentration and specific activity. These aliquots were evaporated to dryness overnight in a vacuum desiccator, oxidized by wet combustion, and the radioactivity determined by proportional counting.

Table II. Effect of Time on Sorption

75-Min. Beaten Pulp, 29,900 sq. cm./g.
Pulp Consistency, 0.0167%
Initial PMG Concn., 0.100 g./l.
pH, 6.5

Time, min.	*PMG specific sorption × 10², a g./g. pulp*	*Calculated residual PMG concn., g./l.*	*Decrease in PMG concn., %*
1	0.678	0.0989	1.1
2	0.921	0.0985	1.5
4	1.18	0.0980	2.0
8	1.38	0.0977	2.3
15	1.72	0.0970	3.0
45	2.68	0.0955	4.5
135	3.67	0.0938	6.2
405	5.17	0.0914	8.6
840	6.13	0.0898	10.2
1680	7.13	0.0881	11.9
3360	8.12	0.0865	13.4
6720	9.05	0.0849	15.1

[a] Average of duplicate analyses.

Details of the Sorption-Time Experiments

In the sorption experiments, separate but identical samples were prepared for each time interval. Sufficient wet pulp for the sorption experiment was weighed on an analytical balance and then dispersed by gentle shaking in a small volume of distilled water contained in a Mason jar. Additional distilled water was then added to adjust the consistency to 0.05%. After standing overnight to be sure that swelling equilibrium had been achieved, 100-ml. aliquots were taken and placed in 500-ml. wide-mouthed screw-capped bottles. The sample bottles were then closed and placed in a controlled temperature water bath.

After the temperature of the pulp slurry reached that of the controlled water bath, a measured volume of PMG solution, similarly heated (or cooled), was introduced and the sorption experiment conducted for a predetermined interval of time. Throughout the sorption run, gentle agitation was provided. Samples were placed on a drum rotating at 12 r.p.m. within the controlled temperature water bath.

At the conclusion of a sorption experiment, the pulp fibers were recovered by filtration and the residual PMG solution removed by washing with distilled water.

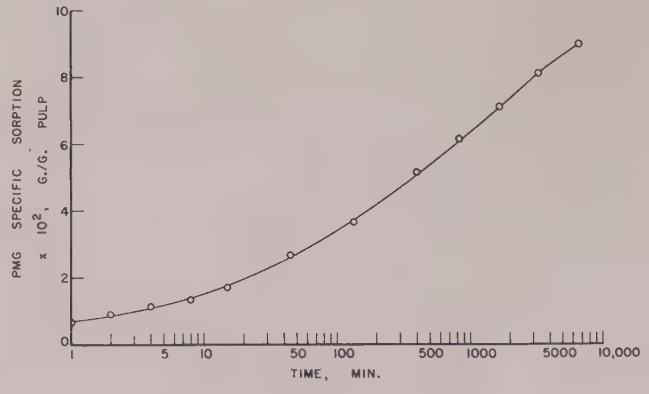

Fig. 1. PMG sorption as a function of time

Table III. Effect of Time on Sorption

35-Min. Beaten Pulp, 11,780 sq. cm./g.
Pulp Consistency, 0.0167%
Initial PMG Concn., 0.100 g./l.
pH, 6.5

Time, sec.	*PMG Specific sorption × 10², g./g. pulp*	*Calculated residual PMG concn., g./l.*	*Decrease in PMG concn., %*
60	0.438	0.0993	0.7
120	0.583	0.0990	1.0
200	0.722	0.0988	1.2
300	0.838	0.0986	1.4
900	1.234	0.0979	2.0

Preliminary experimental studies had established that no significant desorption of PMG occurs during this washing procedure.

Infinite Bath Conditions

From calculations based on the LBG sorption data of Leech (*3*), it was believed that infinite bath conditions could be approached by working at a very low pulp consistency, 0.01%, and high gum concentration, 0.10 g. per l. The effect of time on the initial bath conditions with the sorption of PMG was studied at a pH of 6.5 at a temperature of 25°C.

The most highly beaten pulp planned for use in this study was the sorbent in this experiment. This pulp, beaten for 75 min. prior to classification, had a hydrodynamic specific surface area of 29,900 sq. cm. per g., and thus provided the most extreme conditions of test. The results of this experiment are presented in Table II and Fig. 1.

From Fig. 1, it will be noted that equilibrium conditions for PMG sorption were not achieved in 112 hr. Although the rate of sorption continually decreased with increasing time, the sorption of gum showed no indication of leveling off. In 45 min., a 5% decrease in PMG concentration as compared with initial conditions was noted, and over the course of the sorption experiment the total decrease amounted to 15%.

The question of equilibrium was not pursued further; it appeared more fruitful to consider the sorption phenomena solely from an initial rate standpoint. *Over the first 15 min. of sorption*, the change from initial sorption conditions amounted to only 3%, and therefore an infinite bath condition was approached.

With a pulp of lower specific surface area, the change in PMG bath concentration is less, and therefore conditions are even more suitable for rate studies. In Table III are presented the results of PMG sorption on the 35-min. beaten pulp, using the same conditions for the sorption experiment as those previously used for the 75-min. beaten pulp. In this case, the decrease in PMG concentration over a 15-min. interval was limited to only 2%. It will be shown later from studies of the effect of concentration on rate that changes of this magnitude are not significant.

EFFECT OF TIME AND PMG CONCENTRATION ON SORPTION

The effect of time on the sorption of PMG was investigated using the 35-min. beaten pulp, and initial PMG concentrations ranging from 0.005 to 0.100 g. per l. The pulp consistency was 0.0167% at a pH of 6.5. These sorption runs were conducted at 25 ± 0.2°C.

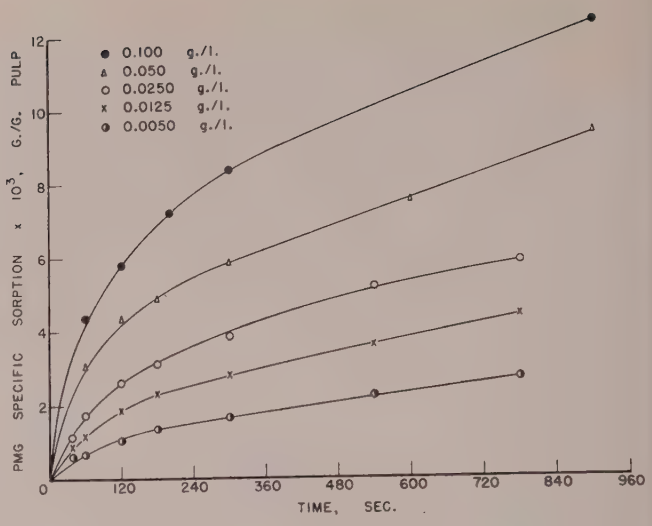

Fig. 2. Effect of time and concentration on PMG sorption

The results of these experiments are presented in Table IV and are plotted in Fig. 2.

In a heterogeneous system such as this, it has been pointed out that both physical transport and chemical kinetic steps may be involved in the over-all sorption phenomenon. Many times an insight into the rate-determining factors in such a system may be obtained from a knowledge of the functional dependence between the initial rate and concentration. Employing the technique described by Livingston (*18*), a plane

Table IV. Effect of Time and Concentration on PMG Sorption

35-Min. Pulp Fraction, 11,780 sq. cm./g.
Pulp Consistency, 0.0167%
Temperature, 25°C.
pH, 6.5

Initial PMG concn., g./l.	*Time, sec.*	*PMG Specific sorption × 10², g./g. pulp*	*Calculated residual PMG concn., g./l.*	*Decrease in PMG concn., %*
0.100[a]	60	4.38	0.0993	0.7
	120	5.83	0.0990	1.0
	200	7.22	0.0988	1.2
	300	8.38	0.0986	1.4
	900	12.34	0.0979	2.0
0.050[a]	60	3.10	0.0494	1.2
	120	4.37	0.0493	1.4
	180	4.89	0.0492	1.6
	300	5.88	0.0490	2.0
	600	7.53	0.0487	2.6
	900	9.42	0.0484	3.2
0.025[a]	40	1.15	0.0248	0.8
	60	1.75	0.0247	1.2
	120	2.67	0.0246	1.6
	180	3.13	0.0245	2.0
	300	3.87	0.0244	2.4
	540	5.20	0.0241	3.6
	780	5.88	0.0240	4.0
0.0125[c]	30	0.834	0.01236	1.1
	60	1.18	0.01230	1.6
	120	1.86	0.01219	2.5
	180	2.32	0.01211	3.1
	300	2.81	0.01203	3.7
	540	3.60	0.0119	4.8
	780	4.40	0.0118	5.6
0.005[b]	30	0.610	0.00490	2.0
	60	0.669	0.00489	2.2
	120	1.05	0.00482	3.6
	180	1.35	0.00478	4.4
	300	1.63	0.00473	5.4
	540	2.21	0.00463	7.4
	780	2.71	0.00460	8.0

a PMG Specific sorption—average of duplicate analyses, single run.
b PMG Specific sorption—single analysis, single run.
c PMG Specific sorption—average of duplicate sorption run, single analysis.

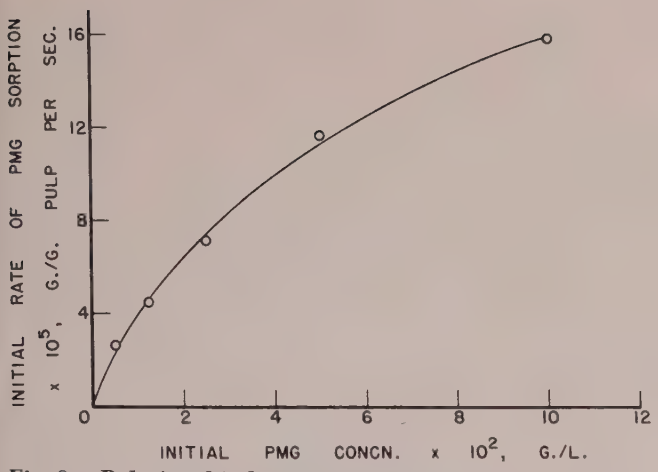

Fig. 3. Relationship between initial rate of PMG sorption and initial PMG concentration

mirror tangentimeter was therefore used to determine the slope, at zero time, of the curves in Fig. 2.

The relationship between the initial rate of PMG sorption and initial PMG concentration is plotted in Fig. 3. It may be noted that increased initial PMG concentrations resulted in an increase in initial sorption rate. The initial rate of sorption was found empirically to fit the equation:

$$R_0 = kc^{0.61} \qquad (1)$$

where

R_0 = over-all initial PMG sorption rate, g./g. pulp per second
c = initial PMG concentration, g./1000 g. solution
k = constant, sec.$^{-1}$

In equation (1) above, k should not be construed as a true reaction rate constant for it may contain hidden components. Daniels (*19*) has pointed out the dangers of inadequate consideration of all the factors involved in studies of rate processes. All too often, data are forced to fit simple relationships where a more complex situation exists. Both diffusional and chemical kinetic effects may be involved in the empirical constant, k. Here, as is explained later in this paper, k is affected by the degree of agitation in the system.

Any hypothesis of the rate-determining factors involved in PMG sorption would have to be consistent with the functional dependence on concentration, as described in equation (1) above. In rate studies, this analysis is normally aided by the criterion of the order

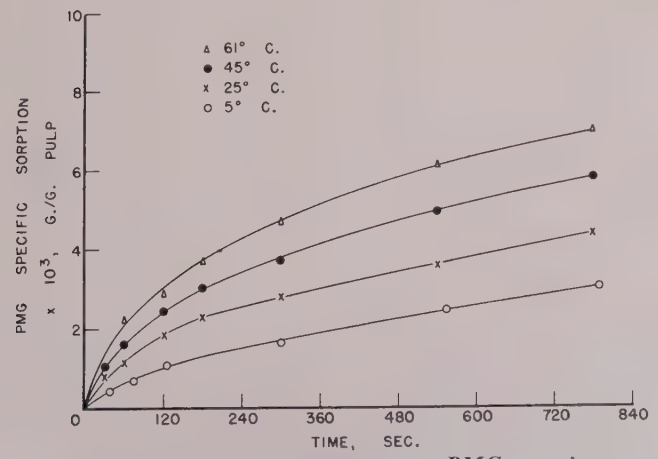

Fig. 4. Effect of temperature on PMG sorption

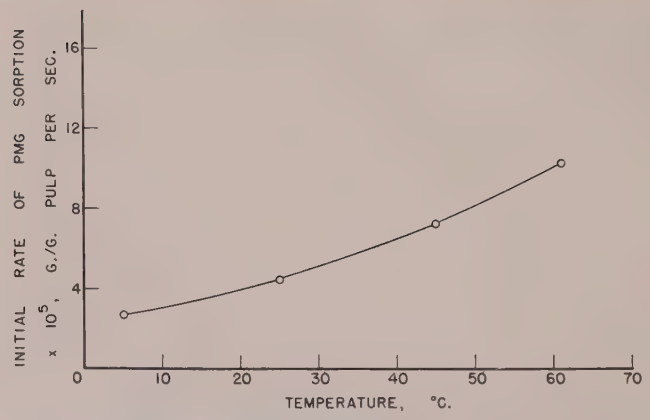

Fig. 5. Relationship between initial rate of PMG sorption and temperature

of reaction. Here, the fractional exponent of the concentration term indicates a complex reaction. Little distinction can be made between the effect of a diffusional transport step or the possibility of a complex adsorption reaction on the over-all initial rate process. Both of these phenomena may be interpreted as consistent with the rate equation noted above.

For a sorption mechanism dependent on a diffusional transport step, the functional dependence on concentration may be either of the first or some fractional order. Where the coefficient of diffusion is a constant, a first-order relationship would result in accord with Fick's law. For a diffusional process in which the diffusion coefficient depended on concentration, a fractional reaction order could be obtained. In polymer systems, this behavior is not unusual (*20*).

Similarly, for an adsorption process, a fractional order with respect to concentration is also possible. For example, Langmuir (*21*) points out that the order of such reactions may be zero, first, second, or some intermediate value.

In summary, the experimentally observed functional dependence expressed in equation (1), between the rate of PMG sorption and concentration, presents an important limiting condition. This is one of the elements which must be met in any ultimate test of a proposed mechanism for the rate processes in this system.

EFFECT OF TEMPERATURE ON SORPTION

The variation of reaction velocity with temperature is a most powerful criterion for assessing the mechanism of any rate process. High temperature coefficients for a reaction usually indicate a chemical process; while, in contrast, a low-temperature coefficient suggests a physical process, such as diffusion or adsorption of the Van der Waals type.

Using an initial PMG concentration of 0.0125 g. per l. and the 35-min. beaten pulp, the effect of temperature in PMG sorption was studied. As in the previous sorption experiments, an infinite bath was approximated by working at a pulp consistency of 0.0167%. The sorption data are plotted in Fig. 4.

The desired temperature dependence of the initial rate of PMG sorption was calculated from the sorption curves in Fig. 4. These data are plotted in Fig. 5. For a 10°C. rise in temperature, the calculated average temperature coefficient is 1.3, which is consistent with a diffusional transport step as rate-controlling in the over-

all sorption phenomenon. A temperature coefficient of 1.3 is reported, for example, by Zimmerman (*22*) for diffusional processes in aqueous systems. This is in contrast with a chemical reaction which generally involves high energies of activation, and in which the temperature coefficient for a 10° C. rise in temperature may range from 2 to 4.

In addition to considering the temperature coefficient of the initial rate of PMG sorption, it is perhaps even more fruitful to consider the energy of activation for sorption derived from this temperature coefficient. Whether one considers the effect of temperature on sorption rate from the standpoint of absolute reaction rate theory or the originally empirical relationship of Arrhenius, the variation in the rate constant may be expressed as (*23*):

$$k = s \exp(-\Delta E_a/RT) \qquad (2)$$

where

k = reaction rate constant
s = constant
ΔE_a = energy of activation
R = gas constant
T = absolute temperature

This equation may be said to be perfectly general, applying to both chemical reactions and physical changes.

Set in logarithmic form, equation (2) may be expressed as

$$\ln k = -\Delta E_a/RT + \ln s \qquad (3)$$

According to equation (3) a straight line is produced when ln k is plotted against the reciprocal of absolute temperature. The slope of such a line equals $-\Delta E_a/RT$ from which the energy of activation, ΔE_a, may be evaluated.

Inasmuch as the specific or true reaction rate constant is an unknown for the PMG-pulp system under study, as has been previously discussed, it is convenient to calculate the energy of activation from initial rate-temperature data. The modified equation would be of the same form as in equation (3), but with the initial rate, R_0, substituted for the reaction rate constant, k, a concentration term appears in the intercept:

$$\ln R_0 = -\frac{\Delta E_a}{RT} + \ln s + 0.61 \ln c \qquad (4)$$

Figure 6 is a plot of equation (4) based on the data of Fig. 5. In Fig. 6, the base of the logarithm has been converted from the Napierian to the Briggsian system. From the slope of the line, an activation energy of 4400 cal. per mole was calculated. The *mole* in the expression for the energy of activation refers to the kinetic unit involved in the rate process. For a physical diffusion process, this reference is made to the solvent; for a chemical reaction or sorption process involving a polymer, this unit cannot be unequivocally defined at present. In such a case, the mole or kinetic unit is usually considered in terms of the reactive segment or number of segments of the polymer chain.

It may be recalled that the energy of activation represents the critical increase in energy required by the constituent molecules of a system prior to their participation in a chemical or physical process. As such, the determination of activation energies has proved to be a valuable aid in the investigation of reaction mecha-

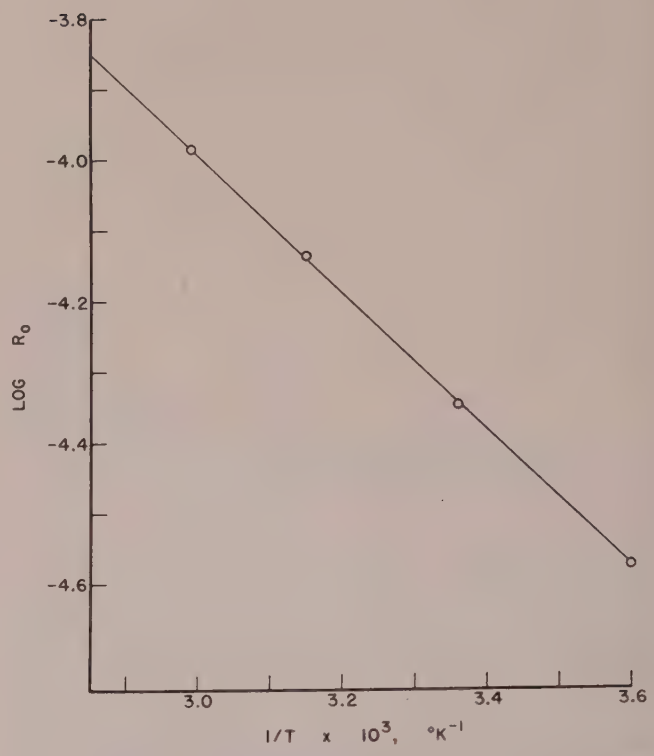

Fig. 6. Initial rate of sorption data in form of Arrhenius Equation for calculation of activation energy

nisms. In many kinetic studies, a consideration of the order of magnitude of the energy of activation provides an insight into the nature of the phenomenon. For example, the range of activation energies for ordinary measurable *chemical* reactions is of the order of 15 to 60 kcal. per mole (*24*). Similarly, chemisorption or "activated adsorption" involves relatively high energies of activation, frequently of the order of 20 kcal. (*23*). In contrast, *physical* processes, such as the flow of a liquid, diffusion in solution, or Van der Waals-type adsorption, require very little activation energy. The processes of viscous flow and diffusion are quite similar, and for normal liquids involve energies of activation of about 3 to 5 kcal. per mole (*23*). For adsorption of the Van der Waals type which is generally accompanied by small *heat* changes, of the order of 5 kcal. or less, little consideration is given to an energy of activation (*23, 25*), the implication being that it is no larger than the magnitude of the heat changes.

In the present research, the calculated energy of activation, 4400 cal. per mole, is most significant. The order of magnitude of this value is indicative of a physical process as rate determining in the over-all PMG sorption phenomenon. A diffusional transport step, adsorption of the physical or van der Waals type, or a combination of both these processes may be involved. Here, chemisorption or a chemical reaction of PMG at the fiber surface are improbable, since such phenomena would involve much greater activation energies.

EFFECT OF AGITATION ON SORPTION

The logical deduction from the observed experimental results of the temperature study is that a physical process is the important rate-controlling factor in the overall sorption of PMG. In the following experiments, the importance of a diffusional transport step was inves-

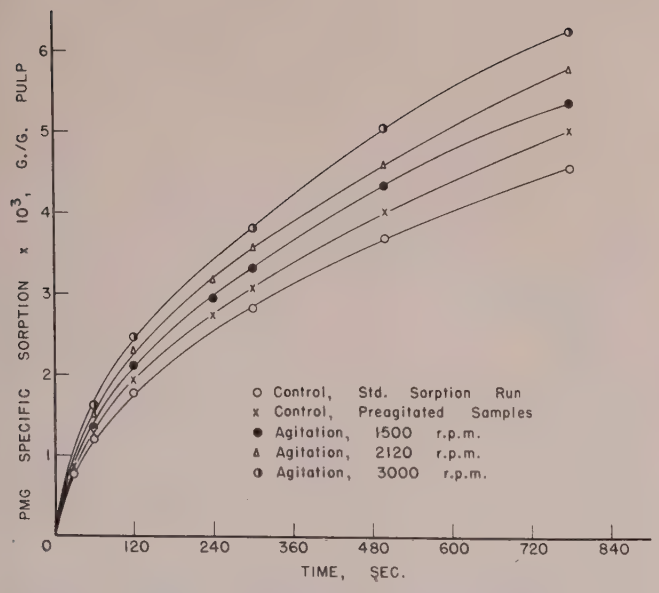

Fig. 7. Effect of agitation on PMG specific sorption

tigated further by studying the effect of agitation on the sorption of PMG. If a physical transport step is important in the PMG-pulp system, then the agitation action, by reducing the resistance to molecular transfer, should result in an increased sorption of gum.

The experiments designed to test the validity of a physical transport hypothesis were conducted on the 35-min. beaten pulp, at an initial PMG concentration of 0.0125 g. per l. The pulp consistency was 0.0167%, and the temperature maintained at 25°C. throughout the sorption runs. These sorption studies were conducted in a standard British Pulp Disintegrator modified to operate at 3000, 2120, and 1500 r.p.m.

In these experiments, it was necessary to consider the effect of agitation on the pulp itself. Ingmanson

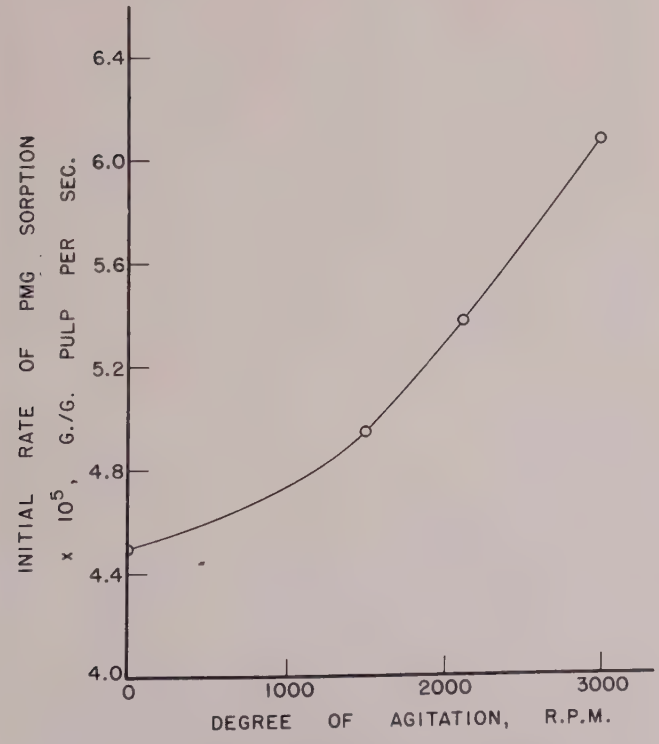

Fig. 8. Relationship between initial rate of PMG sorption and degree of agitation

(*26*) has demonstrated that the hydrodynamic specific surface area of pulp fibers increases with stirring in a British Disintegrator. In addition, other concomitant changes occur; for example, the imbibition of water increases as reflected in the specific volume, and fiber flexibility is affected.

Provision was made in the experimental design for correcting the sorption data for the effect of agitation on the pulp. The increased PMG sorption resulting from modification of the pulp fibers was assessed by means of control runs. These controls consisted of parallel standard PMG sorption runs, made on two series of pulp samples. In one series, the pulp was subjected to agitation in a British Disintegrator at 3000 r.p.m. for 780 sec. prior to the sorption run. Such conditions represent the most extreme action to which the pulp fibers were subjected in the agitation experiments. In the other series, there was no preliminary treatment to the pulp fibers. The difference in PMG retention between these runs represents the effect of agitation on the pulp itself. The sorption data are plotted in Fig. 7.

From curves in Fig. 7, it may be noted that the amount and rate of PMG sorption increased markedly with increasing agitation. The portion of the increased sorption which may be attributed to the modification of the pulp fibers, resulting from agitation, was small. In the most extreme case, at 780 sec., the increase due to this factor amounted to 10%, and at the 60-sec. interval it was but 5%. At 3000 r.p.m., the sorption was as much as 35% greater than that of the reference control run. To obtain a comparable increase by varying the PMG concentration, it would have been necessary to approximately double the initial concentration.

The initial rates of PMG sorption, for the three conditions of agitation, were calculated from the curves in Fig. 7 as previously described, and are presented graphically in Fig. 8. These data are corrected for the effect of agitation on the pulp itself by reference to the control run. A linear correction was applied for the sorption runs at 2120 and 1500 r.p.m., based on the control data at 3000 r.p.m. The calculated initial rates of PMG sorption were not corrected for the slight additional increase in specific surface which may have resulted from the gum being present during the agitation. Although an apparent peptizing effect has been suggested for some related systems, it is felt that, in connection with *initial* rate studies, the influence of such an effect is sufficiently small to be considered negligible.

The marked dependence of PMG sorption on the degree of agitation is a most important experimental observation. It confirms the hypothesis that in the PMG-pulp system, a transport process represents an important rate-determining step in the over-all sorption phenomenon. If a transport step were not important, the observed PMG sorption would not have been influenced by the stirring or agitation action.

The exact nature of this transport phenomenon cannot be completely described at this time. Under the conditions of agitation used in this research, bulk diffusion would not be expected to be a factor of importance. It will be recalled that a tumbling action provided for the constant mixing of the PMG-pulp system throughout the sorption experiments. However, while providing for mixing in the PMG-pulp sus-

pension, this tumbling action was mild, and it may be postulated that a resistance to the transfer of PMG existed at the fiber-liquid interface. Conceivably, this resistance may be present as a stagnant film of liquid from the bulk phase, or as loosely held layers of imbibed water associated with both the fiber and the gum.

It is suggested that the tangential shearing stresses accompanying stirring reduce these resistances and thus enhance the transfer of PMG to the fiber surface. Such an analysis is consistent with a consideration of Fick's first law of diffusion. From Fick's law, an inverse relationship exists between the rate of diffusion and the equivalent resistance to molecular transfer. Thus, a decrease in the equivalent film thickness would manifest itself in an increased rate of molecular transport as was observed here.

EFFECT OF PULP SPECIFIC SURFACE ON SORPTION

In approaching the present study of PMG sorption, a transport process and adsorption proper at the fiber surface were suggested as process steps in the over-all sorption phenomenon. For both these steps, the area involved in the process is an important variable. As such, it is interesting to consider the dependence of PMG sorption on the "surface area" of pulp fibers.

Classically, a diffusional transport process bears a direct relationship with area. On the other hand, for many adsorption processes, the dependence on area cannot be expressed as succinctly because of the complexities of the surfaces involved. For pulp fibers, as with many materials, "surface area" is difficult to define and consequently is often described in terms of the method of evaluation. Here, hydrodynamic specific surface area from filtration resistance measurements was taken as a measure of the "surface area" of the pulp fibers.

The effect on PMG sorption of an increase in pulp hydrodynamic specific surface, as developed by beating, was investigated at one level of PMG concentration and one temperature. The initial PMG concentration was 0.0100 g. per l., the temperature 25°C., and the consistency maintained at 0.0167%. The sorption-time data for pulps having hydrodynamic specific surfaces of 9260, 11,780, 15,610, and 29,900 sq. cm. per g. are plotted in Fig. 9.

As one would expect, the amount and rate of PMG sorption increased with increasing specific surface. The effect of specific surface on the initial rate of PMG sorption was determined from the curves in Fig. 9 as previously described, and are presented in Fig. 10.

A linear relationship is observed in Fig. 10 between the initial rate of PMG sorption and hydrodynamic specific surface area. In view of the concomitant changes which occurred to the pulp with beating, this behavior is especially interesting. From this relationship it may be noted that the rate of change of PMG sorption with respect to hydrodynamic specific surface area is a constant, irrespective of other modifications to the pulp fiber. These data would indicate that the calculated hydrodynamic specific surface area bears some direct relationship to the actual surface involved in the over-all sorption phenomenon.

However, the development of surface area is not the only factor of importance in the sorption of PMG which

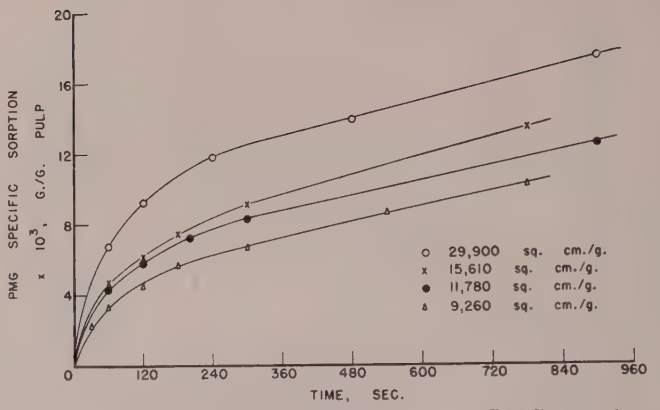

Fig. 9. Effect of pulp specific surface on PMG sorption

changes with beating. For example, at different levels of area development, a given increase in area does not produce equivalent changes in the rate of PMG sorption. A question of accessibility could be involved. Some of the external area developed by beating may be available to water flow in the hydrodynamic specific surface measurement, but not accessible for PMG sorption. On the other hand, a diffusion process may be of importance. Consistent with the basic hypothesis presented in this paper, it is possible that the barrier presenting resistance to transport of PMG molecules is increased by changes in the fiber which occur on beating.

THE NATURE OF PMG SORPTION ON SULFITE PULP FIBERS

In addition to the major conclusion that a transport process is rate determining in the overall PMG sorption phenomenon, these studies made possible a hypothesized characterization of the sorption process itself. Studies of the effect of time on the sorption of PMG by pulp fibers showed that the retention of PMG increased with increasing contact times. The rate of sorption was initially high, decreased very rapidly, but continued at a finite level as is shown in Fig. 11. Since infinite bath conditions were approached throughout the course of the sorption runs, it is improbable that this decrease in rate was caused by a reduction in the concentration of PMG in solution. It is suggested that this phenomenon is a consecutive rate process, involving both deposition of gum on the fiber, and subsequent sorption of gum by the gum-fiber complex. The sorption process, requiring a low energy of activation, is believed to be of the physical or Van der Waals type. Physical dispersion forces from numerous "active

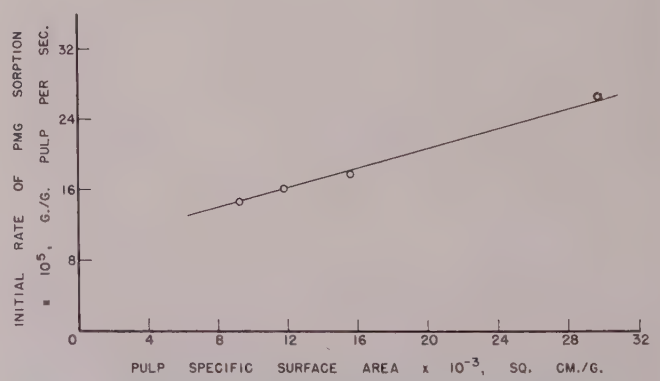

Fig. 10. Relationship between initial rate of PMG sorption and pulp specific surface

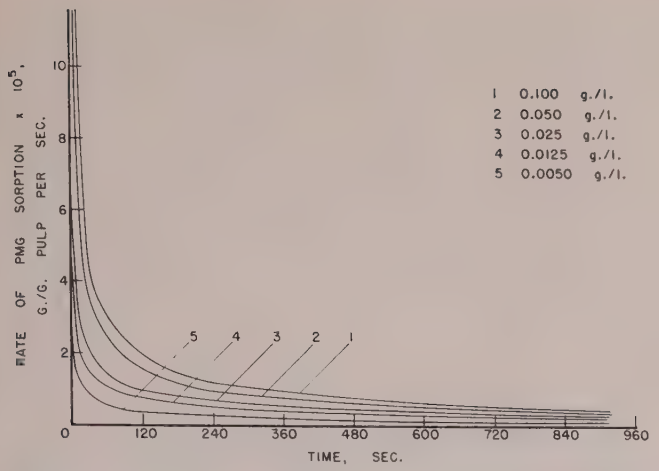

Fig. 11. Rate of PMG sorption as a function of time on Pulp C-II

centers" throughout the cellulose surface are suggested as setting up a force field capable of attracting and holding the PMG molecule. Ultimate retention of the gum is hypothesized to occur via multiple hydrogen bonding, resulting in a high degree of sorption irreversibility.

The above characterization of the sorption process is discussed in greater detail in the thesis upon which the present paper is based (*27*).

INTERPRETATION OF SORPTION EXPERIMENTS

From an analysis of the PMG-pulp system, two steps have been suggested as the important rate-determining factors in the overall sorption phenomenon. These are first, a transport process, and second, adsorption proper at the fiber surface. The experimental results of each of the sorption studies have been discussed in view of these considerations.

The observed temperature dependence of the initial rate of PMG sorption showed a low temperature coefficient. For each 10°C. rise in temperature, the initial rate of sorption was increased by a factor of 1.3. The order of magnitude of this figure is consistent with a *physical* process as rate determining in the over-all PMG sorption phenomenon. The nature of such a process was elaborated by a consideration of the calculated energy of activation for the initial rate of PMG sorption. The figure of 4400 cal. per mole is strongly suggestive of a diffusional transport process, adsorption of the Van der Waals type, or a combination of both these processes as rate determining. Since the value 4400 cal. per mole reflects the rate-determining step in the over-all process, the adsorption step *per se* cannot require a greater energy of activation. Consequently, the possibility of a high energy, slow chemisorption step is excluded. The adsorption proper at the liquid-solid interface must therefore be of the physical or Van der Waals type, and would be expected to be quite rapid. Thus, adsorption *alone* cannot be expected to be rate determining. From this analysis, the adsorption step must occur at a rate in excess of or comparable in magnitude to that of the transport process.

The importance of a diffusional transport step was investigated further by studying the effect of agitation on the sorption of PMG. The initial rate of PMG sorption was noted to increase markedly as the degree of agitation in the PMG-pulp system was increased. At 3000 r.p.m., the initial rate of sorption was as much as 35% greater than that of the reference control run. No such dependence on agitation could have been found for an adsorption-controlled reaction. It was suggested that the tangential shearing stresses accompanying stirring reduce the resistance to molecular transfer and thus enhance the transport of PMG to the fiber surface.

In view of these studies, the conclusion is drawn that a transport diffusional process is the important rate-determining factor in the over-all PMG sorption phenomenon.

APPENDIX I

Calculation of PMG Retention

The manometric carbon analysis of Van Slyke, *et al.* (*24*), followed by proportional counting of the carbon[14] radioactive products provides a simple, straightforward method for determining the retention of polysaccharide beater adhesives on samples of pulp fibers or paper. This method is especially convenient inasmuch as there is no need to determine the sample size independently prior to the radioactive determination for the adhesive. In the PMG-pulp system of this study, the sorption of PMG per unit weight of fiber was calculated from the following formula:

$$x/M = \frac{K_1\,(r/a)}{(\Delta p)(F) - (r/a)K_2}$$

where

x/M = mg. PMG per mg. pulp fiber
K_1 = constant, percentage carbon in pulp fiber
r = counts per minute (cpm), determined by proportional counting
a = specific activity of PMG, cpm/mg.
Δp = pressure of carbon dioxide evolved in Van Slyke combustion at a definite volume and temperature
F = factor, multiplied by Δp gives total carbon in milligrams
K_2 = constant, percentage carbon in PMG

For a given sorption experiment, with a stock solution of known activity, a, this technique involves the measurement of only the variables Δp, the pressure of the evolved carbon dioxide, and r, the cpm of the radioactive carbon[14].

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Free Mono- and Oligosaccharides of Some California Conifers

LESLIE V SMITH and EUGENE ZAVARIN

A survey was made of the free sugars and lower oligosaccharides in the heartwood, sapwood, inner bark, and outer bark of incense cedar, redwood, ponderosa pine, sugar pine, Douglas-fir, red fir, grand fir, white fir, and Pacific yew. Cross sections of freshly cut trees were separated into the four components which were extracted with 80% ethanol. The extracts were clarified by ethyl acetate partition, hide powder, and/or lead acetate and H_2S. Sugars were separated and identified by paper chromatography using four solvents and four spray reagents. Glucose and arabinose were found generally in the heartwood and outer bark of all species. In addition galactose, xylose, fucose, and rhamnose were found in some of the species. Glucose, fructose, sucrose, and raffinose were found in the sapwood and inner bark while stachyose and two unidentified higher oligosaccharides were found in some species, primarily in the sapwoods.

Aside from pines, few conifers have been examined for content and nature of the simple, free carbohydrates present in the wood tissues. Lindstedt reported the presence of free arabinose and glucose in cold water extracts of sap- and heartwood of several pines, including ponderosa and sugar pines (*1*). In his analysis, however, he employed ethyl acetate-pyridine-water as the chromatographic solvent, which does not separate fructose and arabinose. In addition, he used silver nitrate, a chromogenic spray which does not permit differentiation among the various sugars on the basis of different colors produced. Brasch and Wise (*2*) chromatographically identified free fructose, glucose, and sucrose in the cold-water extract of *Pinus radiata* (Monterey pine), presumably sapwood. Sucrose, usually accompanied by glucose and fructose, has been found in "nutrient saps" of *Picea mariana* and *Pinus sylvestris*, with other oligosaccharides possibly present (*3*). Anderson and Erdtman (*4*) isolated L-arabinose from the heartwood of *Thuja plicata*, and Kritchevsky and Anderson (*5*) isolated L-arabinose, and chromatographically identified glucose, galactose, and xylose in *Chamaecyparis lawsoniana* heartwood. Kondo and Furuzawa (*6*) reported glucose and arabinose in *Larix-kaempferi* heartwood, identified by chromatography, and Ahluwalia, *et al.* (*7*), isolated crystalline L-arabinose from the heartwood of *Pinus gerardiana* and *Pinus khasya*.

Although the nutrient saps mentioned probably included the inner bark, coniferous barks have been given even less attention. Anderson and Pigman (*8*) isolated crystalline sucrose from the inner bark and cambial zone of *Picea mariana*. The occurrence of free sugars in the coniferous outer barks apparently has not been investigated.

In spite of the rather limited amount of information, certain regularities seemed to suggest themselves, particularly if considered in connection with a number of investigations on hardwoods mentioned later. Thus, fructose, glucose, and sucrose seemed to be characteristic of the functional tissues, sapwood and inner bark; while arabinose and glucose appeared to be peculiar to the nonfunctional heartwood tissue. The present work was undertaken to substantiate the existence of such a pattern. For this purpose, the heartwood, sapwood, and inner- and outer-bark portions of nine species, representative of the families Pinaceae, Cupressaceae, Taxodiaceae, and Taxaceae, were analyzed chromatographically for their content of the free, simple sugars.

The results of this work are summarized in Table I.

Leslie V Smith and Eugene Zavarin, Richmond, Calif., April 27, 1959.

Table I. Occurrence of Free, Simple Carbohydrates in the Species Analyzed Per Cent Free Carbohydrates[a]—Dry-Weight Basis

Species[b]	Glucose	Fructose	Sucrose	Raffinose	Stachyose	Galactose	Arabinose	Xylose	Rhamnose	Fucose	Unidentified
Outer bark											
IC	0.01	...	...	...	...	0.02	0.03	tr	tr	tr	.
RD	0.02	...	...	...	...	...	0.02	...	tr	...	...
PP	0.3	...	...	...	...	...	0.02	...	...	...	...
SP	0.05	...	...	...	...	...	0.08	...	tr	tr	...
DF	0.03	...	...	...	...	...	0.03	tr	tr	...	...
RF	tr	...	...	...	...	...	tr	...	...	...	...
GF	0.02	...	...	...	...	...	0.01	...	...	...	...
WF	tr	...	...	...	...	...	tr	...	...	...	...
Y	tr	...	...	...	...	...	tr	...	...	...	...
Inner bark											
IC	0.02	0.03	...	...	...	...	...	...	...	...	...
RD	0.2	1.0	0.2	...	...	...	...	...	...	...	...
PP	1.5	1.8	1.5	0.1	...	...	...	...	...	...	...
SP	1.0	1.5	3.3	0.3	...	...	...	...	...	...	...
DF	0.8	1.5	1.6	0.3	...	...	...	...	...	...	...
RF	0.8	1.0	3.0	0.02	...	...	...	...	...	...	...
GF	0.07	0.04	tr	...	...	...	...	...	...	...	...
WF	0.08	0.2	0.1	0.03	tr	...	...	...	...	...	...
Y	0.6	0.6	1.2	tr	...	...	...	...	...	...	...
Sapwood											
IC	0.08	0.05	0.02	0.05	tr	...	...	...	...	...	...
RD	0.1	0.1	0.03	0.03	...	...	...	...	...	...	...
PP	0.04	0.04	0.04	0.02	tr	...	...	...	...	...	tr
SP	0.06	0.05	0.03	0.02	tr	...	...	...	...	...	...
DF	0.1	0.1	0.1	0.02	tr	...	...	...	...	...	tr
RF	0.2	0.2	0.2	tr	...	...	...	...	...	...	...
GF	0.09	0.09	0.2	...	...	...	...	...	...	...	...
WF	0.3	0.2	0.3	...	...	...	...	...	...	...	...
Y	0.02	0.01	tr	tr	...	...	...	...	...	...	...
Heartwood											
IC	tr	...	...	...	...	tr	0.04	tr	tr	tr	...
RD	tr	...	...	...	...	...	0.02	...	...	...	...
PP	tr	...	...	...	...	...	0.3	...	...	...	...
SP	tr	...	...	...	...	...	tr	...	...	...	...
DF	0.02	...	...	...	...	...	0.04	?	tr	...	...
RF	tr	...	...	...	...	...	tr	...	...	...	...
GF	tr	...	...	...	...	...	tr	...	...	...	...
WF	...	...	...	...	...	...	...	...	...	...	...
Y	...	...	...	...	...	...	?	...	...	...	...

[a] Based upon visual comparison of the extract spot with a standard on the same chromatogram. tr—(trace) indicates amounts less than 0.01%.
[b] IC—incense cedar (*Libocedrus decurrens* Torr.), RD—redwood (*Sequoia sempervirens* (Lamb.) Endl.), PP—ponderosa pine (*Pinus ponderosa* Dougl.), SP—sugar pine (*Pinus lambertiana* Dougl.), DF—Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Fran.), RF—red fir (*Abies magnifica* Murr.), GF—grand fir (*Abies grandis* Lindl.), WF—white fir (*Abies concolor* Lindl. & Gard.), and Y—Pacific yew (*Taxus brevifolia* Nutt.).

Certain qualitative patterns peculiar to the different tissues are evident. The functional tissues, inner bark and sapwood, generally contain fructose, glucose, and sucrose, with raffinose and stachyose present in smaller quantities. Ponderosa pine and Douglas-fir sapwoods also contain an unidentified ketose-saccharide (probably a higher saccharide of the raffinose series) with a lower R_f than stachyose. The nonfunctional, outer bark and heartwood seem generally to contain arabinose and glucose. Rhamnose appears in the outer bark of redwood, incense cedar, sugar pine, and Douglas-fir, and in the heartwood of incense cedar. Fucose, also a methyl pentose, was identified in incense cedar outer bark and heartwood, together with galactose and xylose in smaller quantities, and in sugar pine outer bark. No oligosaccharides were found in heartwood or outer barks.

Further work is necessary to determine whether the above relationship also holds for the hardwoods, although there are indications in the literature that it is valid. Thus, for example. Kondo, *et al.* (*9*), chromatographically identified rhamnose, xylose, glucose, and arabinose in *Juglans sieboldiana* heartwood. Reeder and Kremers (*10*) preparatively identified fructose, glucose, and sucrose in *Populus tremuloides* inner bark and sapwood, and detected small amounts of raffinose and kestose chromatographically in the sapwood. The sapwood and inner bark of tanoak (*Lithocarpus densiflora*) contain glucose, fructose, sucrose, raffinose, and stachyose (*11*). Zimmerman (*12*) examined the sieve tube exudates of some 15 hardwoods and found sucrose, raffinose, stachyose, and verbascose, but no monosaccharides, which he believed to be cellular constituents. As with conifers, apparently there are no reports on the free sugar content of the outer barks of hardwoods.

In addition to spots corresponding to the above-mentioned sugars, the chromatograms of outer bark and heartwood extracts produced a number of spots with color and general behavior similar to that of uronic acids; the spots were not present on any chromatograms of freshly processed sapwood. However, spots did appear if the sapwood was stored for a month or more. This could indicate the oxidation of sugars taking place during storage. Another type of change resulting from the prolonged storage at low temperature and high humidity was the appearance of fructose in extracts of heartwood and outer bark.

To substantiate the chromatographic identification of those sugars that have not been identified previously by preparative means in a particular tissue of a conifer, the sugars, where available in sufficient quantity, were eluted from the chromatograms and the infrared spectrum of the residue of the eluate was compared with that of a standard compound (*13*). In this way, the occurrence of arabinose in the incense cedar heartwood; fructose and sucrose in the sapwood of ponderosa pine and inner bark of sugar pine; and rhamnose, fucose,

xylose, arabinose, and galactose in incense cedar outer bark have been confirmed.

EXPERIMENTAL

Collection of Samples

Cross-sections of the several species were obtained from the Southern Cascades and Sierra Nevada Mountains, Calif. and from Roseburg, Ore. These samples were placed in a cold room at 5°C. and 95% R.H. until prepared for extraction. Most of the samples were extracted within 1 week after felling the tree, to avoid the storage-induced changes described previously.

Extraction of Material

Cross-sections were separated, on the basis of color and other characteristics, into heartwood, sapwood, and inner and outer bark portions, and a sample was taken from the center part of each portion to avoid the transition zone material. With the exception of the inner bark, the samples were ground in a Wiley mill to pass a 10-mesh screen. Seventy-five to 600 g. of the resulting material was extracted with 80% ethanol for 8 hr. in a Soxhlet extractor. The inner bark samples were cut into strips and extracted in this form with 80% ethanol for 6 hr., followed by grinding in a Waring blendor in 500 ml. of 80% ethanol for 15 min. The resulting material was treated with 1000 ml. of 80% ethanol, the mixture was allowed to stand for 2 days at 5°C., and the alcoholic extract was separated. The extraction was then repeated twice, and all alcoholic solutions were combined.

The alcoholic extracts were evaporated to dryness at 55°C. and 20 to 50 mm. pressure, the residues were taken up with approximately 200 ml. of water, and the insolubles were removed by filtration. In this way some of the extracts, particularly those of sapwood, gave reasonably clear solutions which required no further purification for the chromatographic analysis. Other extracts, especially those from outer barks, required additional extraction with 100-ml. portions of ethyl acetate. Final clarification was achieved by treating the aqueous solutions with 20 to 40 g. of washed hide powder of the type specified for tannin determinations (purchased from Frank F. Marshall Co., Ridgeway, Pa.). After 1 to 2 days at 5°C., the hide powder was filtered and washed with 300 to 400 ml. of water. To insure that no sugars were being lost by adsorption in this treatment, ten grams of hide powder were soaked in 10-ml. solutions of fructose, glucose, and sucrose, containing 30 to 50 γ of sugar per ml. of water, and the sugar concentration in the filtrate was determined by the phenol-sulfuric acid method of Dubois, *et al.*(*14*).

Chromatography

Separation and identification of sugars were achieved by the descending one-dimensional, and in some cases two-dimensional, paper chromatographic technique. The extracts were applied to 1% ammonia-washed Whatman no. 1 paper, the spots dried in a current of warm air, and the paper strips equilibrated for 6 to 10 hr. in the solvent saturated chamber.

The developing solvents included *n*-butanol-acetic acid-water (52:13:35), ethyl acetate-pyridine-water (2:1:2), *n*-propanol-ethyl acetate-water (7:1:2), and water-saturated phenol (*15*). The developed chromatograms were air-dried at room temperature in a hood before spraying.

Chromagenic agents used were (a) *p*-anisidine phosphate spray (*15*) which, upon heating, produced lemon yellow color with ketoses and with ketose containing oligosaccharides, brown with aldoses, gray-brown with pentoses, and orange-brown with methylpentoses; (b) *o*-aminobiphenyl spray (*17*), which gave brown or gray color with aldohexoses, reacted rather slowly with ketoses to give a buff color, gave a characteristically intense red with aldopentoses, and a brown to orange with methylpentoses; (c) α-naphthol spray (*15*), which reacted only with ketoses to give a blue color; and (d) ammoniacal silver nitrate spray, which was used only to determine the reducing ability of the sugars. The spots produced by the first three sprays fluoresce in ultraviolet light with slightly different colors, which aids the identification of sugars.

The variations in reactivity and colors permitted identification of arabinose and fructose, which were inseparable with the solvents employed; the first sugar reacted preferentially with *o*-aminobiphenyl spray and the second with α-naphthol spray.

Identification by Infrared

To confirm chromatographic identification of those sugars not previously identified through preparative means, a modification of the infrared technique of White, *et al.* (*13*), was applied to the eluates of the chromatograms. A portion of the extract was placed on Whatman no. 3 paper in a series of spots 0.5 in. apart, with necessary marker spots for locating the sugars after development. One or two developments using *n*-butanol-acetic acid-water or *n*-propanol-ethyl acetate-water afforded satisfactory separation. The portions of the paper containing the sugars were excised, and eluted with water. A 400 mg. portion of potassium bromide was added to the eluates, and the resulting mixtures were dried under an infrared lamp for 2.5 to 3 hr., with frequent stirring. The dried powders were homogenized in a Perkin-Elmer vibrator, pressed into pellets, and spectroscopically analyzed with a Perkin Elmer Model 21 infrared spectrophotometer. To obtain the reference spectra, water solutions of respective known sugars were used instead of eluates since the crystalline state markedly changes the character of a spectrum (*13*, *16*). Although the spectra obtained were not very sharp as a rule, the positions of the maxima, particularly in the "fingerprint" region, afforded satisfactory identification.

SUMMARY

The heartwood, sapwood, inner and outer bark tissues of a number of conifers were chromatographically analyzed for the free sugars present. Definite patterns characteristic for these tissues seem to be present. Thus arabinose, glucose, together with galactose, xylose, and certain methylpentoses seem to be peculiar to the heartwood and outer bark. Glucose, fructose, sucrose, together with raffinose and stachyose seem to be characteristic for the sapwood and inner bark.

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The Effect of Resin Properties on Extrudability in Paper Coating and Properties of the Coated Paper

JOHN F. MORRIS

An increase in polyethylene density used for paper coating gives the advantages of increased stiffness, tensile strength, temperature resistance, surface hardness, abrasion resistance, and impermeability to various gases, liquids, and greases. This density increase gives the disadvantages of less resistance to heat aging, lower production rates, higher power consumption. Even though the base resin costs are higher in the medium density range, it is less costly to use these materials if the purpose of coating is resistance to permeation of moisture. If the reason for coating is to upgrade a paper product or provide a heat-sealable surface, it is more advantageous to use a lower density polyethylene.

Paper is being coated commercially today to improve its surface quality, to protect a product to be packaged in it from foreign elements, or to facilitate sealing in the packaging operation. These are all very different reasons for coating a substratum so the considerations used in selecting the proper polyethylene must, of necessity, be quite different. After we select the proper polyethylene, based on the physical properties required in the end product, we must consider what properties will be required to make the mechanical coating operation successful and attempt to correlate these requirements.

Polyethylene is used for coating many materials such as foil, cloth, cellophane, glassine, glass mesh, board, and various types of paper. The reasons for coating these materials can be any one or more of the ones we have already mentioned.

When coating the various materials we have mentioned, we must take note of the fact that there are two completely different types of bonds which we encounter. When rough or porous materials are coated, the adhesion is accomplished by forcing the polyethylene into the substratum, either by penetration or interlocking. If this bond is made efficiently, it cannot be broken without destroying or damaging the substratum material.

The other type of bond we encounter depends on molecular attraction rather than mechanical interlocking for its adhesion and is used when coating cellophane, foil, and other very smooth surfaces.

Adequate adhesion to such porous materials as kraft paper requires good fiber penetration and good surface contact, while good electrochemical adhesion requires good surface and a polyethylene structure that will exert a strong electrochemical force in conjunction with the substratum. Because polyethylene is inert and nonpolar, it does not normally exert the necessary electrochemical forces to effect a good molecular bond. Controlled extrusion conditions such as high stock temperatures will give polyethylene the polarity required to adhere to smooth surfaces.

Because the coating of kraft paper and similar materials is by far the largest part of the coating business, we will limit ourselves to mechanical bonds which are encountered in this type coating procedure.

For the sake of convenience, we will confine our discussion to the commonly used segment of the ever-expanding line of products classified as low and medium density polyethylenes. These will include five base resins having densities ranging from 0.913 to 0.934 g. per cc. and melt indices from 1.26 to 8.09 g. per 10 min. See Table I for resin properties.

In general, there are three measurements used to classify polyethylenes and a brief review of the categories and their effect on the mechanical coating process and the physical properties of the finished coating is in order.

RESIN PROPERTIES

Melt Index

If density and molecular weight distribution are held constant, a decrease in melt index will cause the following to happen:

Extrusion	Coating properties
1. Viscosity increases	1. Tear strength increases
2. Minimum thickness increases	2. Tensile strength increases
3. Neck-in decreases	3. Coefficient of friction decreases

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Molecular Weight Distribution

If melt index and density are held constant, a narrowing of the molecular weight distribution will have the following effects:

Extrusion	Coating properties
1. Extrusion becomes more difficult in high shear dies	1. Tensile strength increases
2. Vicat softening point increases	2. Brittleness temperature decreases
3. Smoking decreases	3. Flexibility increases
4. Odor decreases	4. Odor retention decreases

Density

If the melt index and molecular weight distribution are held constant, an increase in the density will have the following effects:

Extrusion	Coating properties
1. Neck-in increases	1. Wicking decreases
2. Viscosity increases	2. Stiffness increases
3. Softening temperature increases	3. Abrasion resistance increases
	4. Tear strength decreases
	5. Permeability decreases

COATING PROCEDURES

To study the effect of certain resin properties on various physical properties of polyethylene-coated kraft paper, a statistical experiment was designed to learn as much as possible about this cause and effect relationship.

Since extrusion conditions figure in physical property quality so significantly, an attempt was made to maintain these conditions as nearly constant as possible, so the results could be analyzed statistically with little difficulty. Naturally, this was not entirely possible because the experimental design called for several coating weights.

The extrusion work in this experiment was done on an 8-in. Hartig extruder using a polyethylene temperature of 610°F. and a paper take-off of 150 ft. per min.

Table I. Properties of Polyethylene Resin

	A	*B*	*C*	*D*	*E*
Melt index, g./10 min.	8.09	4.18	2.48	1.26	4.26
Density, g./cc.	0.9132	0.9182	0.9285	0.9326	0.9342
Tensile strength, p.s.i.	1438	1500	2205	2220	2252
Yield strength, p.s.i.	1400	1450	2105	2220	2252
Elongation, %	517	500	300	500	194

This is a relatively slow take-off rate for the lower density resins but was chosen as a constant to ensure adequate adhesion when the higher density resins were used. If it had been necessary to adjust the web speed to obtain adhesion, this would have introduced a variable that could not have been easily handled in the analysis of the test work.

After the entire design of the processing phase of the experiment had been executed, using three coating weights and five polyethylene resins, a statistical design was made for the physical testing section of the experiment. To do this, the 15 samples were tested for bond strength, tear strength, heat seal strength, moisture vapor transmission rate (MVTR), and greaseproofness.

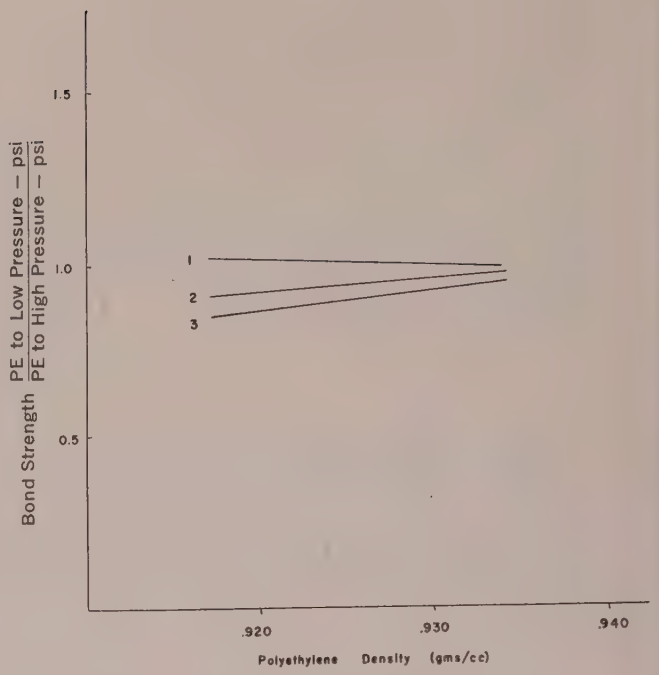

Fig. 1. Bond strength versus polyethelene density, 7 lb./ream on 50-lb. kraft

COATING PROPERTIES

Density Change

In the experimental system which we shall discuss, it was observed that the 0.918-density resin produced a coating having a density of 0.914 the 0.928-density resin dropped to 0.923, and the 0.933-density resin dropped to 0.926 g. per cc. Because the magnitude of this density drop is so dependent on extrusion conditions, the graphs we shall use for the illustrations have been plotted on the basis of the original resin densities.

Bond Strength

The bond strength testing was done first to insure that all samples were of sufficiently good quality to

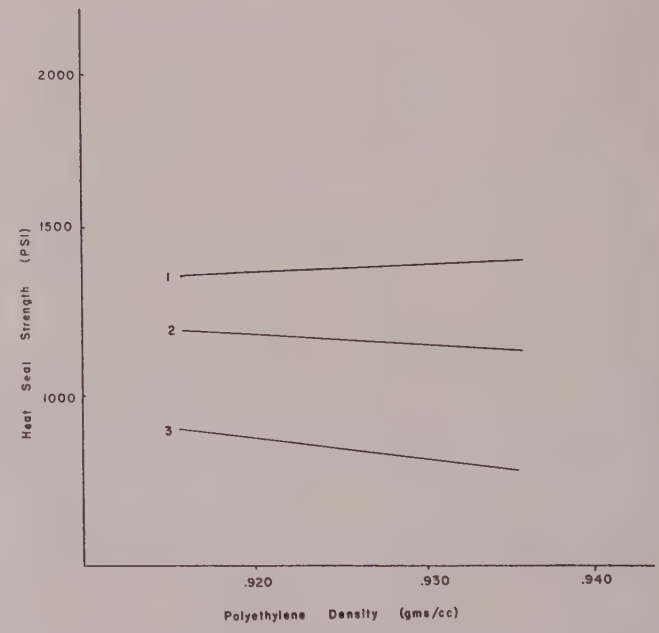

Fig. 2. Heat-seal strength versus polyethylene density, 7 lb./ream on 50-lb. kraft

warrant further testing. This testing was done with a Southwick-Perkins bond-strength tester. The results were reported as the ratio of the burst pressure of the laminate with the polyethylene to the low pressure side over the burst pressure of the laminate with the polyethylene to the high pressure side. Therefore, a good bond gives a ratio of 1, while a poorer bond gives a ratio <1.

As can be seen in plot 1 of Fig. 1, the bond strengths of all the samples were as good as could be expected. The fact that some of the values are slightly above 1 is a result of experimental error.

Because of the various tests which must be conducted on barrier materials for military approvals, some additional bond-strength testing was done. In plot 2 of Fig. 1, we see the results of bond testing on samples which were aged for 24 hr. at 160°F. before testing. The slope of this line shows that the higher density resins are slightly less susceptible to heat aging. From other experience, we know that this is not necessarily so when higher melt index versions of the higher density resins are used.

Plot 3 of Fig. 1 shows the bond strength data which were accumulated on samples which had been soaked in water for 48 hr. at 73°F. and then aged for 24 hr. at 160°F. before testing. The slope of this line shows even more acutely that the higher density coatings are less susceptible to abuse than are the lower density coatings.

Tear Strength

The tear strength of the 15 samples were tested using a standard Elmendorf tear-test method. To confirm the bond strength data already obtained, the samples were tested with the polyethylene toward as well as away from the knife. Since these values were identical within the range of test error, it was confirmed that the bond strengths were of optimum value.

Because of polyethylene orientation the tear strengths were all slightly better in the transverse direction than in the machine direction. The phenomenon of orientation is nearly always observed when polyethylene is extruded through a linear die. No correlation could be drawn between variation in tear strengths and the physical properties of the base polyethylene. This may have been because the differences were so small that they were completely overshadowed by the tear strength of the substratum, which was 50 lb. kraft paper.

Heat Sealability

The heat-seal strengths were determined using three different sample preparation procedures based on certain tests required for military approval of barrier materials. As is shown in plot 1 of Fig. 2, the heat seals were made under optimum conditions using samples which were in the "as received" condition. As would be expected, the heat-seal strengths were slightly better for the higher density resins because of their inherent higher tensile strengths.

The test results illustrated in plot 2 of Fig. 2 were determined on samples which had been aged for one week at 158°F. and then aged another week at 158°F. and 60% R.H. before sealing. The level of this line shows that this aging before sealing has a detrimental

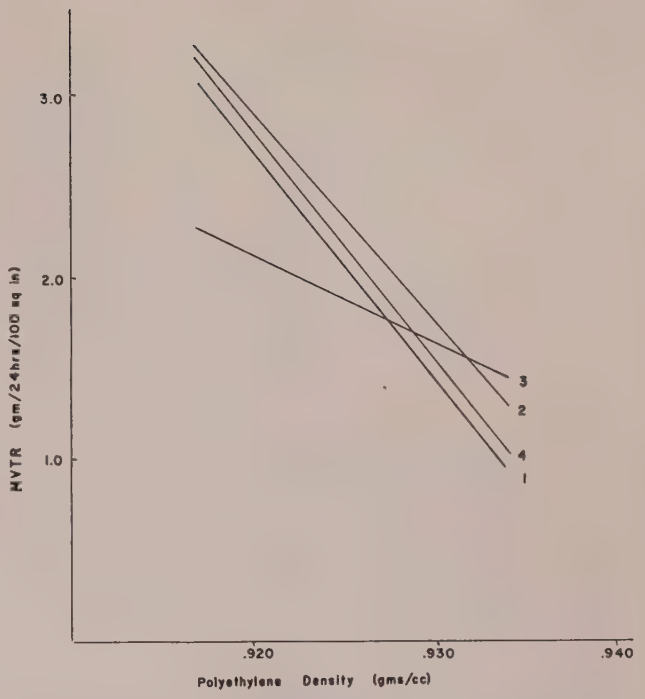

Fig. 3. MVTR versus polyethylene density, 7 lb./ream on 50-lb. kraft

effect on the tensile strength of the polyethylene and the slope of the line shows that it is more serious with the higher density resins.

The data illustrated in plot 3 of Fig. 2 were determined on samples which were aged for one week at 158°F. and an additional week at 158°F. and 60% R.H. after sealing. This shows that the aging after sealing has an even greater detrimental effect on seal strength and the slope of the line shows that the higher density resins are more seriously affected than the lower density resins.

Moisture Vapor Transmission Rate

Moisture vapor transmission rates were tested according to the methods set forth in various military

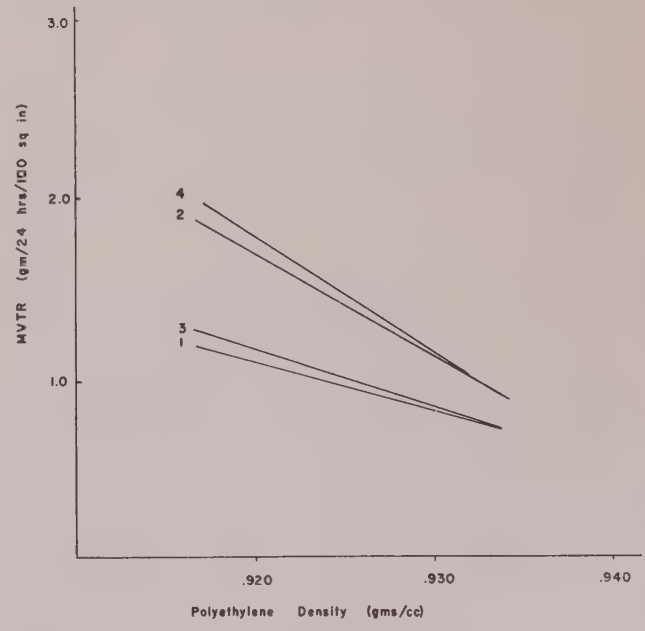

Fig. 4. MVTR versus polyethylene density, 14 lb./ream on 50-lb. kraft

specifications. These tests are designed to show moisture leakage due to wicking and crease susceptibility as well as the inherent permeability of the coated paper.

Plot 1 of Fig. 3 shows the effect of creasing without the effect of wicking on a 7 lb. per ream coating. Plot 2 shows the effect of creasing combined with the effect of wicking, so the difference between plots 1 and 2 is the net effect of wicking.

Plot 3 shows neither the effect of wicking nor the the effect of creasing and is probably most indicative of the resin permeability without destructive testing variables included.

Plot 4 shows the effect of wicking without the effect of creasing.

It cannot be said that the MVTR's at 0.928 and 0.933 densities are from different populations, because of test error. However, this graph definitely shows that low density resins are susceptible to creasing damage at 7 lb. per ream coating weights because of the point on plot 3 at 0.918 density which is definitely from a different population than the other points on this density line.

Figure 4 shows the MVTR data determined on the samples having a coating weight of 14 lb. per ream.

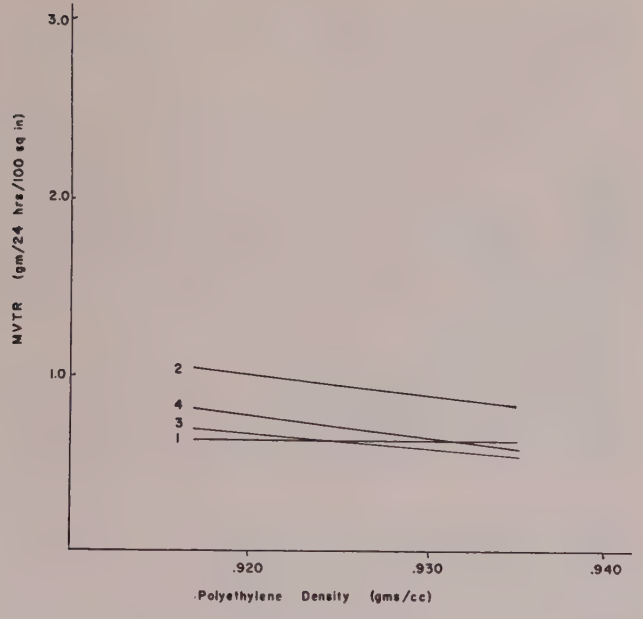

Fig. 5. MVTR versus polyethylene density, 28 lb./ream on 50-lb. kraft

The small differences between plots 1 and 3 and between 2 and 4 were caused by creasing of the sample. The large difference between the two pairs was caused by wicking. This graph shows that the higher density resins are less susceptible to both creasing and wicking when the coating weights are increased to 14 lb. per ream.

Figure 5 has been plotted showing the MVTR of paper having a coating weight of 28 lb. per ream. We see that the difference between plot 1 and 3 is the effect of creasing without the effect of wicking and there is no discernible difference outside the range of test error. The difference between plots 3 and 4 is the effect of wicking without the effect of creasing. The difference between plots 2 and 3 shows the combined effect of wicking and creasing. This, of course, is the worst possible combination of conditions in this test system and the slope of these lines shows that the higher densities give slightly better MVTR's.

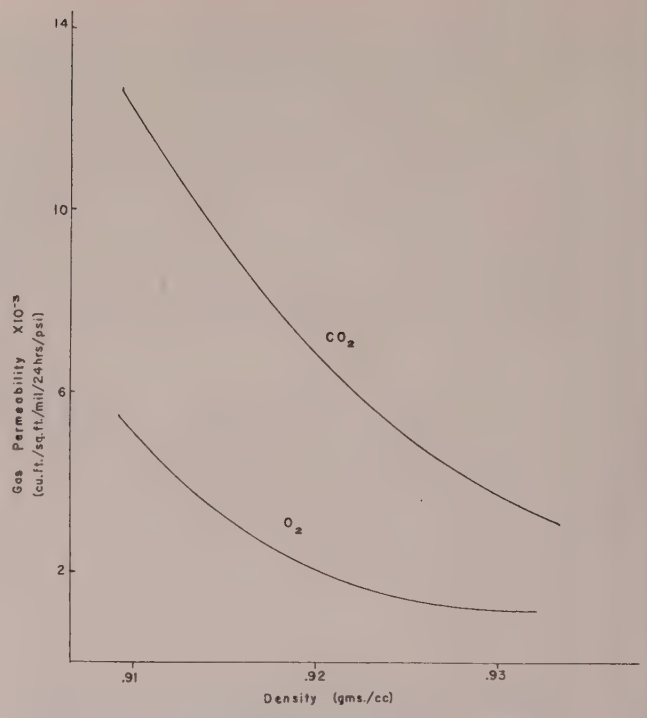

Fig. 6. Density versus gas permeability

Gas Permeability

Figure 6 shows the permeability rate of oxygen and carbon dioxide as related to the density of the polyethylene coating. This work was done on 7, 14, and 28 lb. per ream coatings but the permeability units are on a *per mil* basis, so the various weights were used

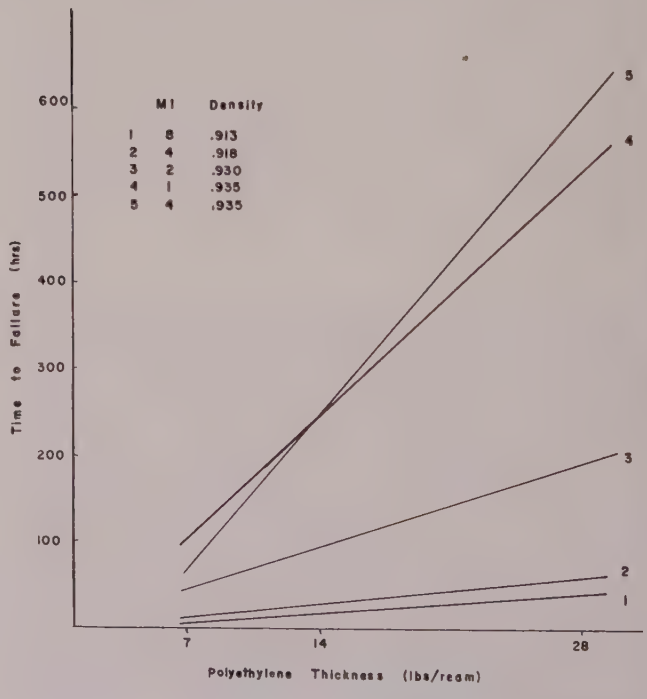

Fig. 7. Greaseproofness versus polyethylene thickness

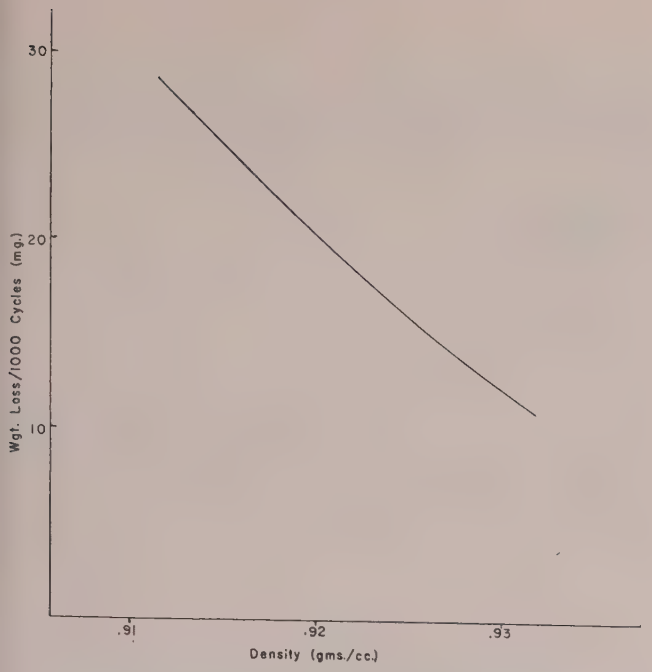

Fig. 8. Density versus abrasion resistance

merely to raise the confidence level of the test work.

This graph shows that there is a drastic change in the permeability rate of these gases in the density range between 0.91 and 0.93 g. per cc.

Greaseproofness

The greaseproofness tests which were done in this work were designed to give a quantitative value rather than a pass-or-fail result as is the case in the methods in the government specifications.

The method specifies that the samples shall be creased diagonally and a kerosene and dye mixture shall be placed on the polyethylene side of the intersection of the crease. When the red dye shows on the substratum the sample shall be considered at the failure point.

Figure 7 was plotted from the empirical results of the work and shows that there is a very definite relationship between the density of the polyethylene coating and grease resistance properties.

Plot 1 had a density of 0.913; plot 2, 0.918; plot 3, 0.930; and plots 4 and 5 had a density of 0.933. Plots 4 and 5 had the same density but different melt indices, yet we cannot say there is a difference in greaseproofness outside the area of test error.

Abrasion Resistance

The various coated samples were placed on a standard Taber Abraser using CS-17 wheels with 1000-g. weights and checked for resistance to abrasion. It was observed that the abrasion resistance of the higher density resins was much better than those observed for the lower density resins. In the density range tested, this relationship is almost a straight line.

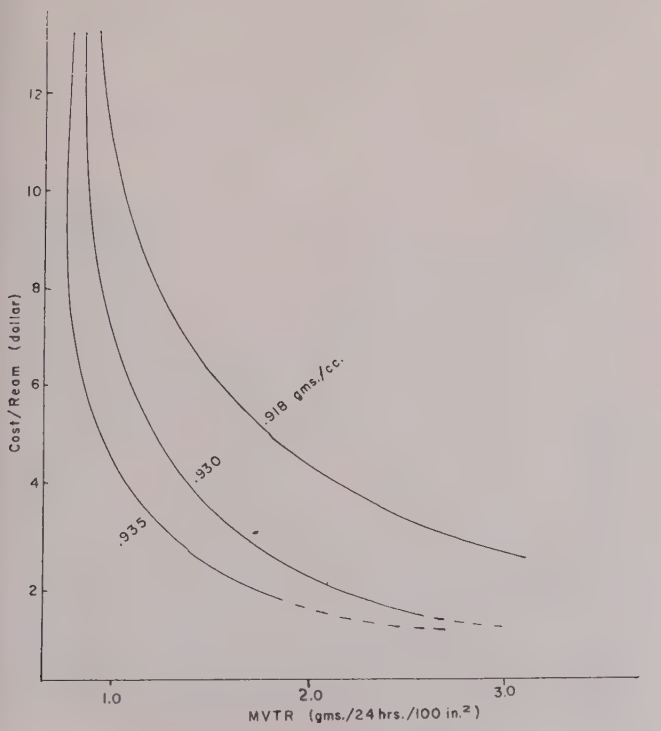

Fig. 9. MVTR versus polyethylene cost

COST

Probably the most important physical property to be considered in coated kraft paper is the moisture vapor transmission rate since so many products are being packaged today which must be protected from moisture.

By assuming a resin cost of 35¢ per pound for the 0.918- and 0.930-density resins and a cost of 42¢ per pound for the 0.935-density resins, we can use the data from Figs. 3, 4, and 5 to plot a cost versus MVTR relationship. This graph is shown as Fig. 9 and points up the fact that even though the 0.935-density resins are more expensive per pound, they are cheaper to use if we are buying a level of moisture vapor protection.

SUMMARY

Extrusion. The important properties to be concerned with in the coating process are melt index, molecular weight distribution, and density.

A medium to low melt index should be used to balance neck-in, extensibility, and flow properties.

A narrow molecular weight distribution should be used to minimize smoking and odor problems.

The intermediate density resins are more difficult to extrude but can be tolerated if the physical properties warrant.

Physical Properties. Increased density gives the advantages of increased stiffness, tensile strength, temperature resistance, surface hardness, abrasion resistance, and impermeability to various gases, liquids, and greases.

Increased density gives the disadvantages of less resistance to heat aging, lower production rates, higher power consumption.

Even though base resin costs are higher it is less costly to use an intermediate density resin if the criterion for coating is permeability.

If the reason for coating is to upgrade a paper product or provide a heat-sealable surface, then it is more advantageous to use a lower density polyethylene.

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Scanning Basis Weight and Moisture Gage Systems on Paper Machines

BRUCE W. SMITH

The advantages of scanning systems are presented with emphasis on "across machine" profile information presentation. The available types of scanning basis weight and moisture gage systems are surveyed and the advantages and limitations are tabulated. The locations of beta gage measuring systems on paper machines are assessed from the point of view of the machine speed and the proposed use of the information. Results are reported from an integrated basis weight-moisture gage system in operation at Rolland Paper Co., St. Jerome, Que., and future systems involving multigaging installations are proposed.

DURING ten years of beta gaging history in the paper industry, the moisture content of basis weight has been acknowledged and ignored. Similarly, moisture gaging systems have admitted to interference by the fiber portion of basis weight but for the large part, they too have chosen the path of "least resistance." No matter what the basic approach has been in the past, the emphasis now and in the future is on the simultaneous measurement of these two important and related variables. Before discussing some of the experience with an integrated basis weight moisture gage system, a review of scanning systems presently available for basis weight and moisture measurement and control is presented.

This discussion is restricted to scanning systems because it is felt that the inherent advantages of the information presentation, i.e., both profile and machine direction, more than compensate for the added cost and space requirements of such systems.

Progress in paper gaging equipment has been from the "fixed point system," such as early beta gage installations and the pilot drier systems, to the more elaborate electro-mechanical traversing mechanisms as are being presented today. An intermediate step utilizing the advanced measuring techniques in combination with sampling methods has resulted in such instrumentation as the beta gage profiler for basis weight measurement and electronic moisture gage units for use in the lab. In particular, profiler units have contributed to the eventual acceptance of the beta gage in the paper industry and to several outstanding programs in the study of basis weight uniformity (*1–3*).

ADVANTAGES OF SCANNING

Scanning system comprises an electro-mechanical device which enables one or more measuring devices to tranverse the entire web of a paper machine at predetermined speeds and at programmed intervals. The advantages of such an approach to gaging systems are as follows:

1. By measuring the entire web, scanning measurements present the best opportunity for obtaining an *average* basis weight and moisture for purposes of machine direction control, either manually or automatically.
2. "Across machine" profile measurement allows point by point comparison of the entire web for "across machine" distribution of moisture and basis weight.
3. Presentation of the profile and average measurements can be on precalibrated direct reading scales. Almost without exception, "fixed point systems" are of the deviation from zero type of presentation.
4. Monitoring of both the measurement and control system, as well as the ambient conditions of measurement, is available by virtue of periodically moving the gaging system off the web. This insures maximum reliability for control functions.

Undoubtedly in choosing a system, one must consider both the immediate and the future use of the equipment, and scanning systems must warrant serious consideration on all paper machines because of their inherent "potentiality for control."

SYSTEMS AVAILABLE

The principal types of scanning beta gage and moisture gage systems available are presented in Tables I and II. A partial list of the advantages and limitations of each method is given; however, for detailed technical information, reference should be made to the various suppliers and published technical papers.

WHERE TO MEASURE ON THE MACHINE

The choice of where to locate beta and moisture gages on paper machines is limited by the space requirement and the proposed use. Moisture gages are invariably associated with the dry end of the paper machine where the per cent moisture content approximates 10% or less. This location includes points ahead of the size press, before or after calender stacks, or at the reel.

Beta gages, on the other hand, may be located virtually anywhere on a paper machine where space is available. As a general rule, however, if only one beta gage unit is being considered, and the machine speed is greater than 500 f.p.m., then a dry end location is preferred. On relatively slow machines, serious consideration should be given to locating the first unit at the wet end. The 500 f.p.m. differentiation is based on two characteristics of measurement and control of basis weight on paper machines, i.e., the "capacity lag" of the stock system and the "transport lag," proportional to the length of paper from the head box to the reel. The "capacity lag" of the stock

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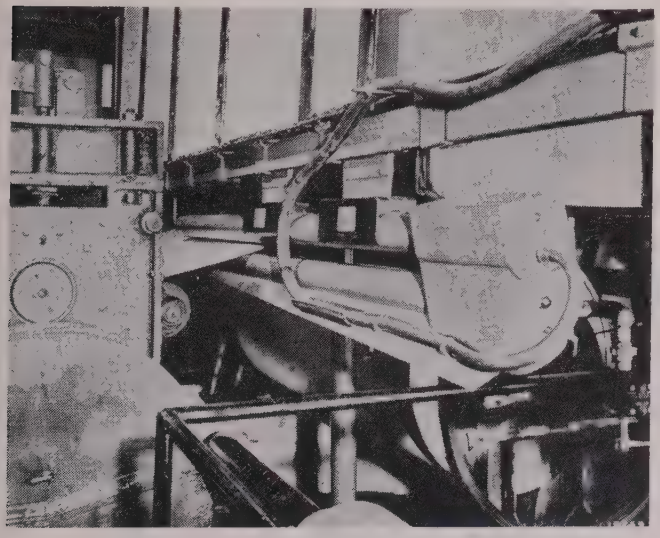
Table I. Scanning Beta Gage Mountings (*4, 5, 6*), Advantages, and Limitations

Principle of measurement	*Advantages*	*Limitations*
Transmission type with the source and detector mounted on opposite sides of the web by means of either a large C frame mounting (Fig. 1) or O frame (Fig. 2).	1. Measuring system completely removed when threading sheet. 2. May have moisture gage associated with the same traversing system when located at dry end. 3. Readily accessible for maintenance. 4. Ambient conditions of measurement, such as, temperature most favorable. 5. Source detector geometry can be suitably arranged to minimize composition effects with simplified calibrations, and minimized pass line sensitivity. 6. Source detector system may be readily cleaned from paper hangups.	1. C frames require more than the equivalent trim width behind the machine for retraction and generally limited to approximately 150 in. or less. Generally, space with a fixed pass line is difficult to find. 2. O frames have the same disadvantages of space on the machine but in addition generally require the sheet be passed by ropes through the frame to the reel.
Reflection gage with the source and detector mounted on the same side of the web (Fig. 3).	1. Out of the way location utilizes space of no previous value and thus represents optimum convenience for operating personnel. 2. Eliminates pass line problems by fixed reference to drier or reflecting surface. 3. Minimizes chances of paper hanging up on measuring system.	1. May require special reflecting surface, i.e., drier surface preparation. 2. More critical mechanical tolerances. 3. More critical to composition effect. 4. Not adaptable to addition of moisture gage. 5. More difficult to service.

system contributes a delay between the amount of control at the stuffbox and the effect of the basis weight change as it appears after the slice. This time delay is of the order of 2 to 3 min. on most paper machines. The "transport lag" is a function of the length of paper from the slice to the reel and is inversely proportional to the paper machine speed. If the "transport lag" is equal or greater than the "capacity lag," then the wet end gaging offers substantial savings in making grade changes because of the prevue of basis weight offered.

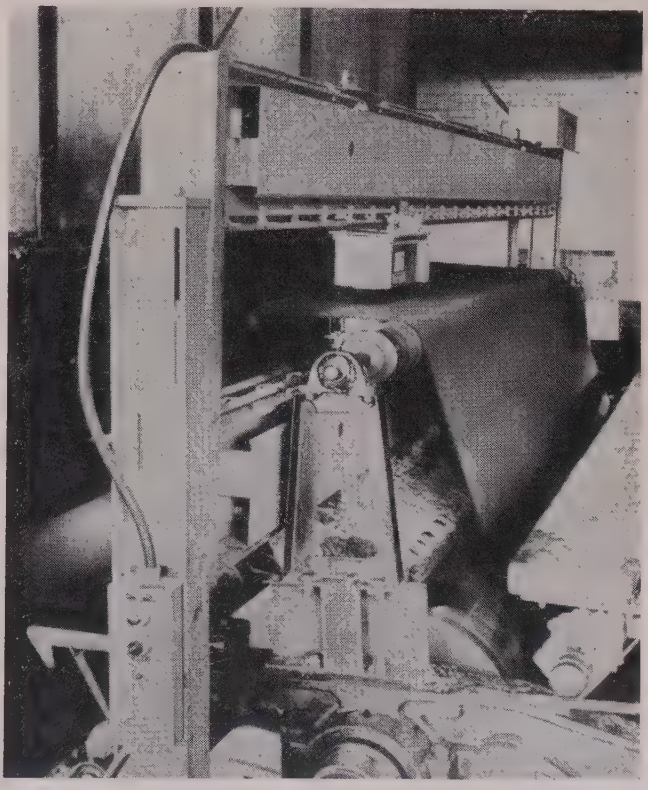
Wet-end beta gages are becoming increasingly important in the operation of paper machines since they serve in the unique manner of monitoring the total mass entering the drier system. Water removal surveys as conducted by Huyck Felt and originally reported by Osborne and Wicker (*12*) have demonstrated the substantial savings which can be obtained by "tuning" the wet end of the paper machine. Similarly, other studies (*13, 14*) have pointed out the value of wet end gaging for assessing such variables as wire pit level changes, running-in of felts, press crown, suction box vacuums, and the vacuum couch.

One of the principal disadvantages of a wet end beta gage system alone is the question of differentiating in a weight change as to whether it represents either a true basis weight variation or is a change in moisture content. If one can assume stable operating conditions on the paper machine as regards head box consistency to speed, press settings, headbox level, and basis weight, then a moisture variation occurring at the wet end of the machine most likely could be attributed to a change in drainage on the wire perhaps associated with a change in stock condition of refining, proportioning, or temperature. In order to account for wet end basis weight changes which might be associated with only a moisture change, a dry-end basis weight change is added and the comparison of the two records readily made. Thus if both the wet- and dry-end basis



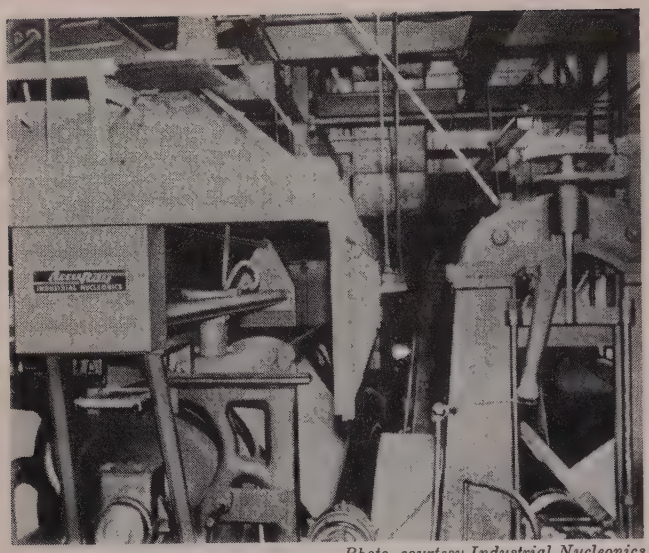
Photo, courtesy Buckeye Cellulose Co.

Fig. 1. Large traversing "C" frame



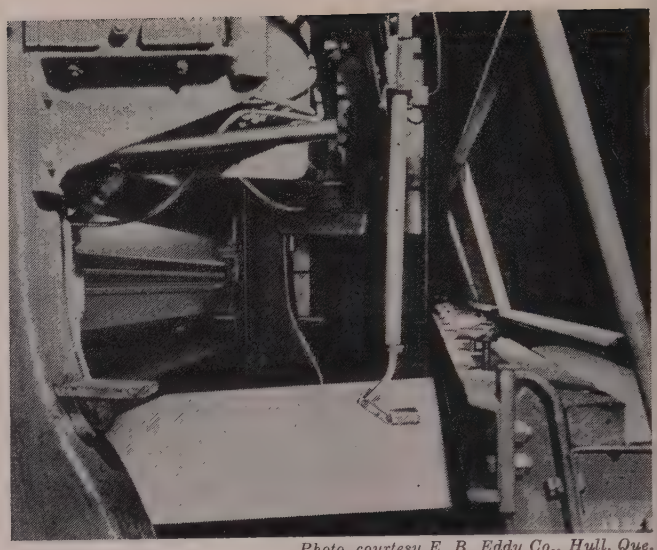
Photo, courtesy Upson Paper, Lockport, N. Y.

Fig. 2. "O" frame beta gage



Photo, courtesy Industrial Nucleonics

Fig. 3. Reflection gage traversing system



Photo, courtesy E. B. Eddy Co., Hull, Que.

Fig. 4. Aquatel moisture gage illustrating a.c. conductivity measurement

weight records are parallel for the same portion of the production, then any variation is readily interpreted as an over-all basis weight change. However if the dry end record remains constant while a variation occurs in the wet-end basis weight record, then there is a change in the per cent moisture's entering the drier system. Such tandem systems are becoming more popular and Downington Paper of Downington, Pa., has two of its cylinder machines so equipped with wet end-dry end O frame scanning beta gages. The information as presented from tandem gages is on four individual recorders (Fig. 6), i.e., basis weight average and profile at the wet end and basis weight average and profile at the dry end. Sample charts from this installation are illustrated in Fig. 7.

INFORMATION PRESENTATION

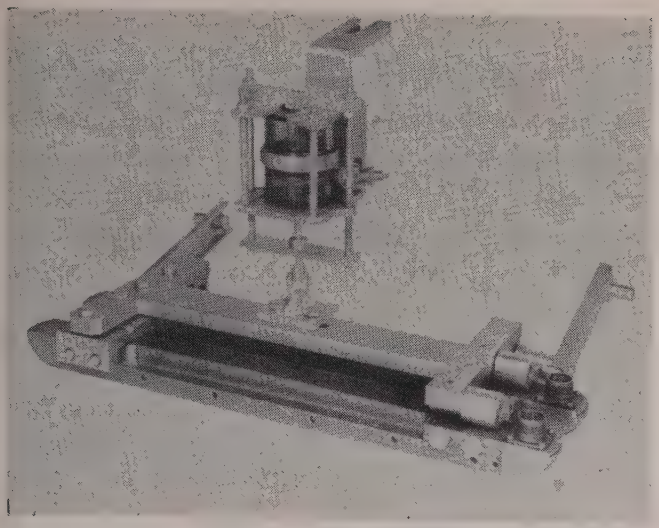
Often the acceptance of gaging systems by the people who are using the equipment is predicated on the clarity and accuracy of the information presentation. Early in beta gaging history, direct reading scales and wide strip chart recorders were first justified to management as an operating record which could be easily interpreted by operators for control purposes and by management personnel for economic justification studies. This conventional approach to recording the machine direction averages is still valid since it has the advantages of high readability, ready trend detection, and is unambiguous as a final product record. It can be argued that with good automatic controls these records are merely straight lines; however, this presumes a degree of reliability with the equipment and confidence in the process that has not yet been attained.

Little attention has been paid to the profile records from which the operator is expected to make a "trend analysis" and presumably take corrective action. Often the profile information has been presented in such a way as to be of no use for fine local adjustments but only as a rough indication of the over-all profile. For example, Fig. 8 is a typical chart sample from a scanning C frame gage on a 110-in. trim paper machine. The entire width is compressed into approximately $1^1/_2$ in. of chart, making it extremely difficult to visualize what adjustments, if any, are required. One of the solutions to spreading out this chart information was to supply a higher rate of chart feed or a two speed chart with the higher speed associated with the profile function; however, both of these methods do not allow ready comparison of profiles. A fairly recent development in the recording field, the X-Y recorder, seems to be an ideal solution.

Basically, the X-Y recorder is a modification of a standard single pen recording system but providing a means of plotting one variable as a function of another. When used with scanning systems, the Y-coordinate

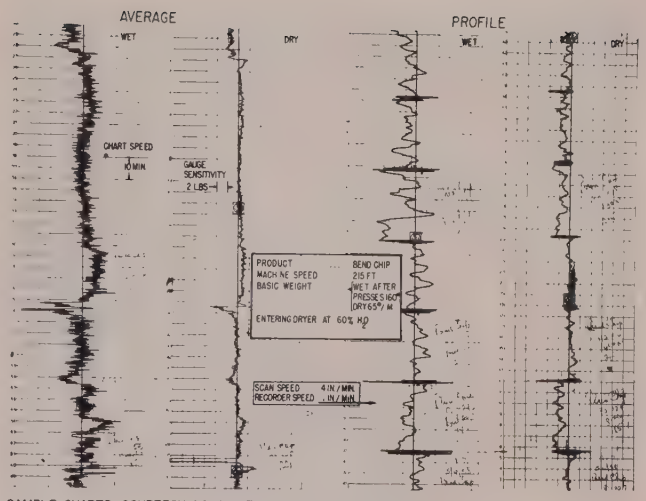
Table II. Scanning Moisture Gages

Principle of measurement	*Advantages*	*Limitations*
1. A. C. conductivity (Fig. 4) (*7*).	1. Not affected by static electricity. 2. Insensitive to contact pressure. 3. Calibrated directly in per cent moisture. 4. High sensitivity to moisture, i.e., conductivity change by factor 5 for each 1% moisture. 5. Insensitive to basis weight variations. 6. Contact from one side only.	1. Temperature affects measurement. 2. Effected by pH variations and additives of electrolytic nature. 3. Maximum range of operations 12% as limited by the resistance of various furnishes. 4. Unit limited to operations on fourdrinier or single cylinder machines.
2. Capacitance (Fig. 5) (*8–11*).	1. Not affected by pH. 2. Range up to 20%. 3. Contact from one side of web. 4. Not affected by temperature. 5. May be calibrated directly in per cent moisture. 6. May be used on multilayered paper.	1. Moisture signal affected equally by basis weight and moisture. 2. Additives, such as clay and titanium oxide, can cause errors in reading. 3. Pickup head capacitance may be altered by lint or dirt. 4. Requires positive pressure on web.



Photo, courtesy, Foxboro Co.

Fig. 5. Capacitance type scanning moisture gage



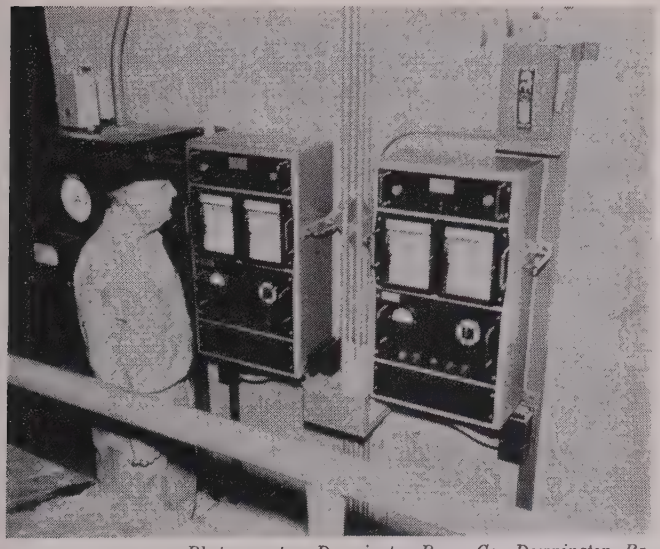
SAMPLE CHARTS COURTESY DOWNINGTON PAPER CO. DOWNINGTON, PA.

Fig. 7

(vertical axis) accepts a measurement signal from either a moisture, basis weight, or moisture-free system while simultaneously the position of the measuring head on the web is plotted on the X-coordinate (horizontal axis). At the end of each scan cycle, the chart paper automatically advances, ready to receive the next profile plot. This chart advance is adjustable to allow the consecutive profiles to be superimposed for comparison purposes or spread out to as much as 6 in. apart. In general practice the spacing is of the order of 1 in., allowing eight profiles to be visible at one time in the viewing area of the recorder. An additional feature allows automatic profile monitoring whereby preset limits may be positioned on the Y axis as obtained from practical operating experience. Should the profile exceed this preset limit as measured by the scanning system, then a warning light or an audible alarm is actuated.

The response time of the measuring system is adjusted to give useful information, yet not confused with unnecessary details. Table III sets forth three measuring times and an estimation of the sample sizes which were utilized in making a series of profile records which are in turn illustrated in Fig. 9. Set A shows the highest resolution with the shortest measurement time and a large amount of detail in the profile is obtained. This detail can result from both the high resolution in the scanning direction and the possibility of short term variations in the machine direction being superimposed upon the profile. As the measurement time is lengthened, a lower resolution and more averaging is encountered until with set C where the information becomes most reproducible and most useful. The sample area increases very rapidly as a function of both the increased averaging in the "across machine" direction and the machine direction.

The adage that a picture is worth a thousand words seems most appropriate with this new profile presentation. As a historical note, although the X-Y recording system is now being used much more extensively, its application to the presentation of scanning basis weight profile was originated by Noel Obenshain of West Virginia Pulp and Paper in Luke, Md., back in 1955. A sample chart from this installation is shown in Fig. 10.



Photo, courtesy Downington Paper Co., Downington, Pa.

Fig. 6. Console cabinet and 4 recorders

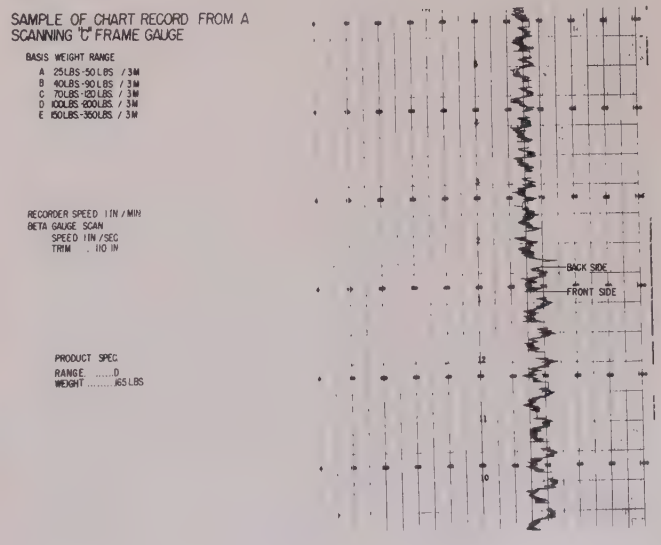

SAMPLE OF CHART RECORD FROM A SCANNING "C" FRAME GAUGE
BASIS WEIGHT RANGE
A 25 LBS - 50 LBS / 3M
B 40 LBS - 90 LBS / 3M
C 70 LBS - 120 LBS / 3M
D 100 LBS - 200 LBS / 3M
E 150 LBS - 350 LBS / 3M
RECORDER SPEED 1 IN / MIN
BETA GAUGE SCAN
SPEED 1 IN / SEC
TRIM .110 IN
PRODUCT SPEC
RANGE .....D
WEIGHT .....165 LBS
BACK SIDE
FRONT SIDE

Fig. 8

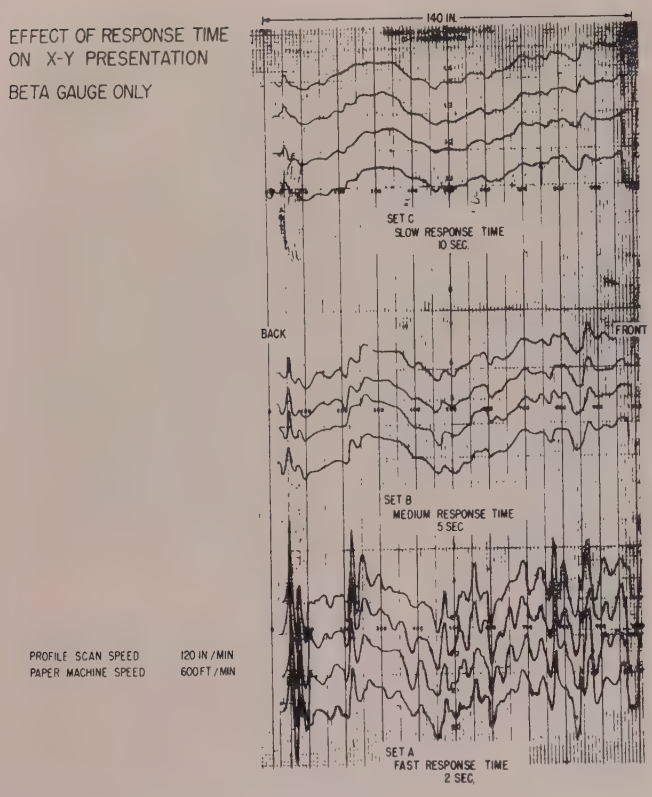


Fig. 9

USING THE PROFILE INFORMATION

Even with reproducible records available, there is still considerable hesitancy in making profile adjustments, particularly because of the difficulty in obtaining reproducible effects. In many instances the practical experience on the machine has been, if it is operating satisfactorily, then it is best left alone. *Where* and *when* to make adjustments are difficult and highly technical questions to answer.

The difficulty in pinpointing the point of *where* to control has been considerably clarified by an excellent study by W. Cuffey (*3*) in which he has noted the interaction of the slice and the basis weight behavior after discrete changes at the slice. There is a notable lack of resolution due to spindle interference and this warp apparently extends to at least one spindle on either side of the point of adjustment in the same direction of adjustment and may give an opposite effect at spindles ±2.

The question of *when* to make a correction at the slice, of course, poses a problem which is the summation of all of the difficulties of the wet end of the paper machine. Theoretically, if a head box is functioning properly (and disregarding the contribution of the fourdrinier and drier system), the slice could be set up at the start and would never require adjustment. Of course, slices are adjusted to compensate for other factors in the operation of the paper machine, such as, poor drainage, pressing, drying, and calendering. The effect of poor wet end piping and the arrangement of the accessory equipment has been reported (*15–16*) and must be taken into consideration for the optimum adjustment of the slice. A recent report (*17*) by Nick Reitzel of Rice Barton concerning the evaluation of their new stock inlet on the new Glatfelter paper

Table III. Profile Sample as Defined by a Scanning Beta Gage

Set	*Measuring time, sec*	*Sample width, in.*	*Sample length, in ft.*	*Sample area, sq. ft.*
A	2	4	20	6.6
B	5	10	50	41.6
C	10	20	100	166.6

Paper machine speed—600 f.p.m.
Profile scan speed—10 f.p.m.
Sample measuring width—3 in.

machine indicates that the optimum slice setting on this particular machine would be ±2% from the fiber weight specification. This conclusion was arrived at by measuring 200 ft. of oven dried machine direction paper on a Foxboro profiler and the maximum fiber deviation was ±2%. In actual operation basis weight profiles of the order of ±3.5% variation are obtained. The 200 ft. machine direction sample represented something of the order of 12 sec. of operation at their nominal 1000 f.p.m. machine speed.

Although it is apparent both from practical experience and this very brief technical introduction that the setting of the slice for fiber distribution is a very complex problem, nevertheless, improvements can be made by using combination gaging in setting paper machine slices. Undoubtedly the trend will be to improved mechanical linkages which will allow independent and individual readings of the slice settings. Combining this slice position information with the fiber profile is a fundamental step toward assisting in making a more uniform sheet of paper.

COMBINATION GAGING

Combining basis weight and moisture measuring systems represents a technological advance in paper machine instrumentation over and above the individual

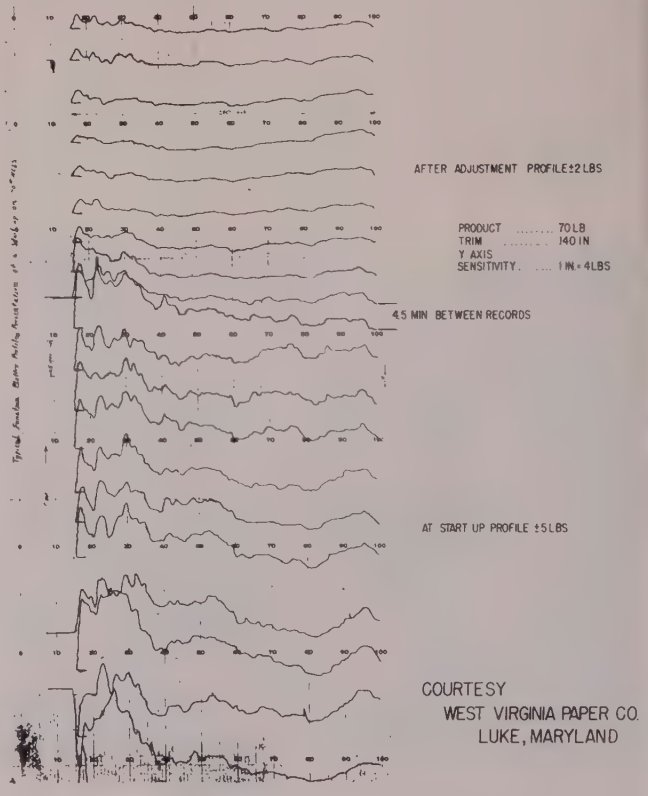

AFTER ADJUSTMENT PROFILE±2 LBS
PRODUCT ..... 70 LB
TRIM ..... 140 IN
Y AXIS SENSITIVITY. .... 1 IN = 4 LBS
4.5 MIN BETWEEN RECORDS
AT START UP PROFILE ±5 LBS
COURTESY
WEST VIRGINIA PAPER CO.
LUKE, MARYLAND

Fig. 10. X-Y chart record

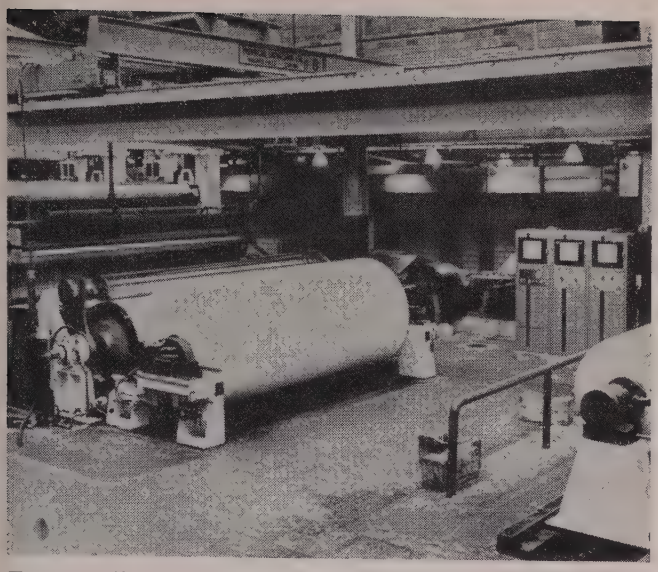


Fig. 11. "O" frame combination showing location at the calender stack, Rolland Paper Co., St. Jerome, Que.

systems because for the first time, it allows the separation of basis weight into the independent variables of fiber and moisture. Perhaps more important is that the separation of these two variables logically leads to a separation of the control functions on a paper machine.

Considering the control of fiber and neglecting the contribution of the fourdrinier wire in its distribution, then control must functionally end at the slice lip of the headbox. By the same token and excluding the effects of stock proportioning and consistency regulation, moisture control starts at the slice and ends at the reel. Combination basis weight-moisture gaging offers the only practical method for the production control of these two interdependent variables.

ROLLAND INSTALLATION

The first fully integrated combination of scanning beta gage and moisture gages has been placed in operation at Rolland Paper at St. Jerome, Que., during the latter part of January, 1958. This mill is most progressive in instrumentation and has been using beta gage equipment continuously since 1952. Automatic basis weight control from an "on the edge" beta gage at their mill was reported in 1953 (*18*). Also the beta profiler has been utilized for 3 years in checking "across machine" profiles among all their paper machines.

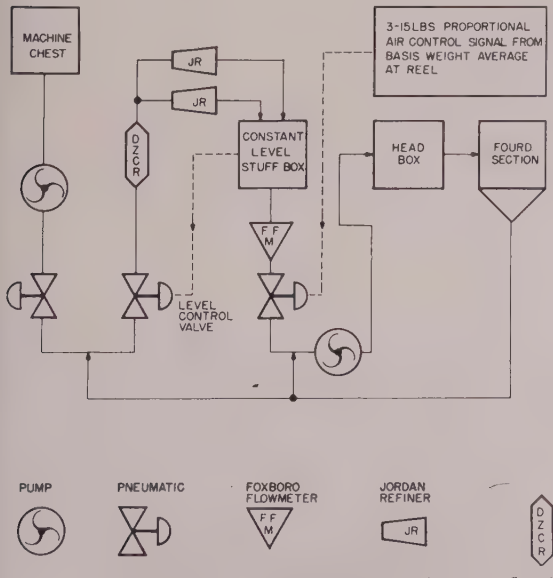
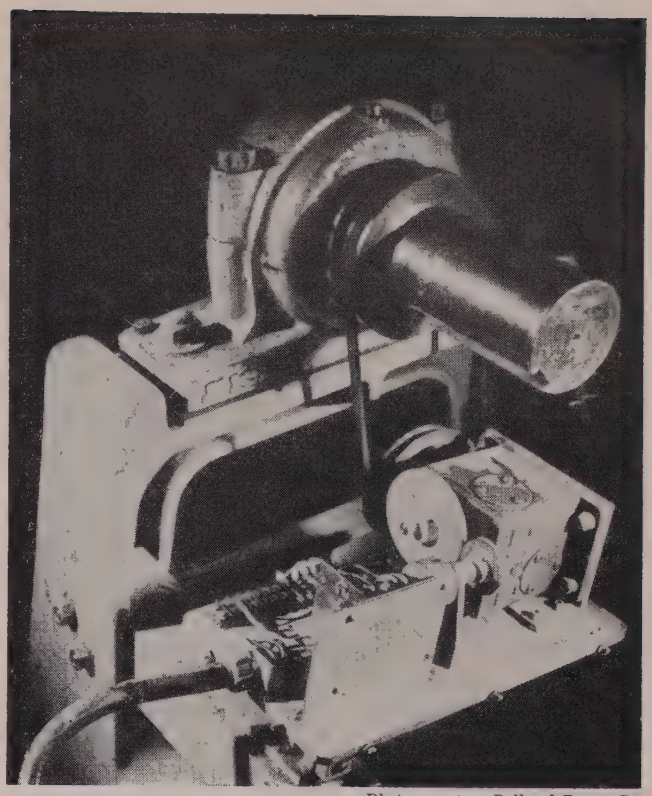


Fig. 12. Schematic diagram, Rolland paper basis weight control system



Photo, courtesy Rolland Paper Co.

Fig. 13. Transport lag control lockout

While planning their new no. 7 paper machine, they looked for the most modern approach to paper machine gaging and decided on the combination of scanning moisture and beta gaging as supplying both their immediate and future requirements. The St. Jerome mill offers a striking contrast of the old and the new with 75 years of operating history, side by side.

A comprehensive report on the Rolland paper machine was published in the April, 1958 issue of *Pulp and Paper Magazine.*

The measuring portions of the gaging system are located on an O frame mounting system after the second calender stack and before the reel. In this location it is necessary to hand pass the sheet through the O frame. The choice of this location was based on the fact that the second calender stack had associated with it a vapor spray system and it was necessary to place the combination gaging ahead of the point where the spray would meet the sheet. Other installations at higher speeds have the O frame placed immediately ahead of the reel and the sheet is passed by means of rope guides.

The recording systems and associated electronics are located in three console cabinets at the back side of the paper machine near the reel, and are shown in Fig. 11. The cabinet at the left houses the Aquatel measuring and recording equipment, the second console contains atuomatic control units and programming systems for the X-Y recorder, and the right hand console houses the beta gage measuring system and presents average basis weight readings.

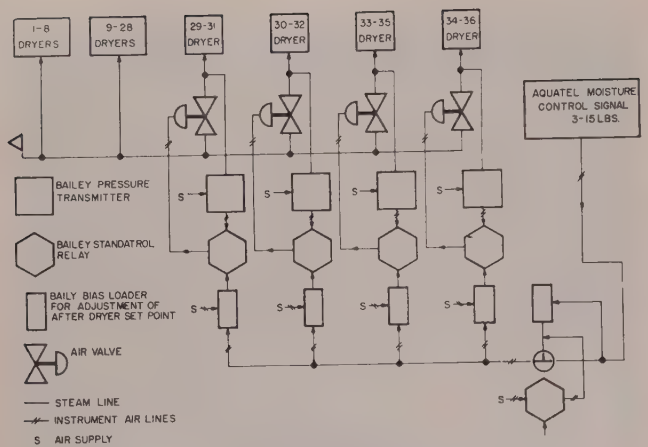


Fig. 14. Rolland moisture control system

Basis Weight and Moisture Control Systems

The integration of the beta gage and moisture gage measuring equipment into the paper machine control network requires a detailed knowledge of the instrumentation and the process. At Rolland Paper it has been our very good fortune to work with a group having much practical experience with beta gages gathered over 6 years and an enormous paper mill instrumentation background. The entire design, layout, and installation of the no. 7 paper machine instrumentation is a fitting tribute to their abilities.

Basis Weight System

The paper machine stock system as involved with the beta gage is outlined in Fig. 12. Not shown on this schematic diagram is the "transport lag" device which is driven from the machine drive. Whenever the beta gage initiates a control cycle, then a cam-operated microswitch arrangement is started which automatically precludes any further controls until sufficient time has elapsed for the first control to be detected at the reel. This time delay is inversely proportional to the machine speed and at approximately 600 f.p.m. represents a $2^1/_2$ min. delay time. The "transport lag" unit is shown in Fig. 13.

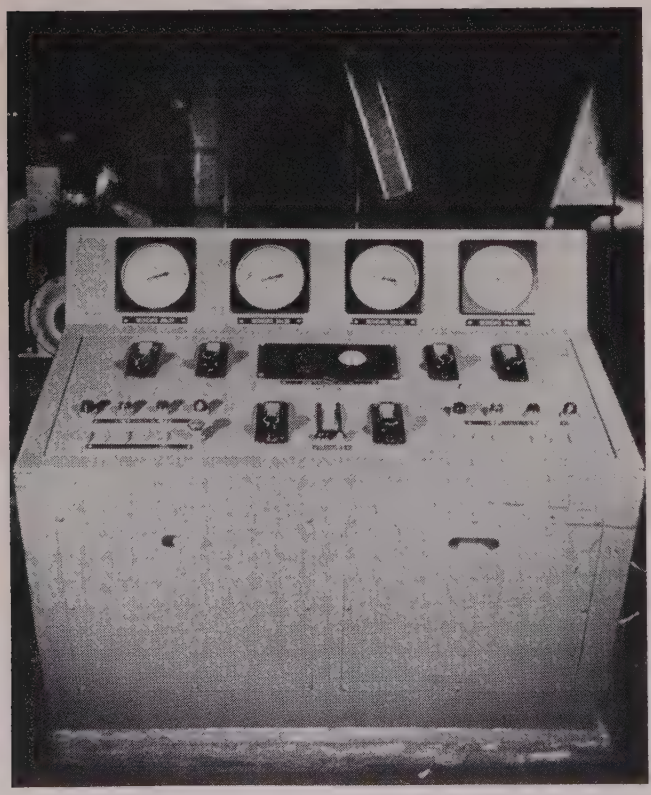


Fig. 15. Drier control console

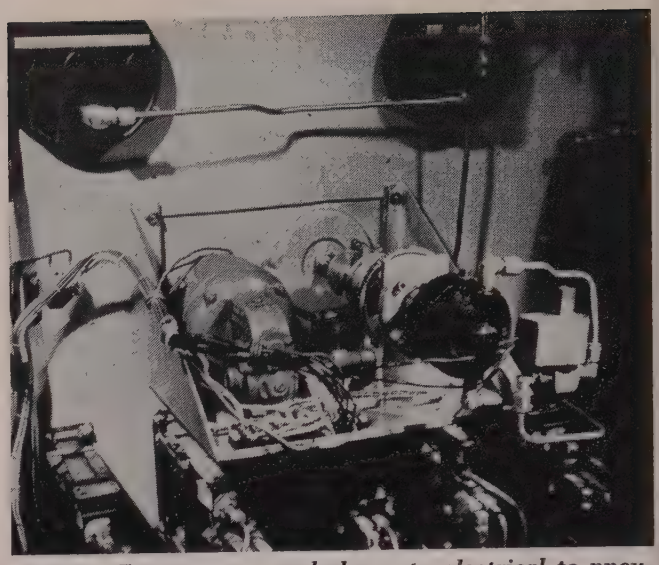


Fig. 16. Beta gage control element; electrical to pneumatic transducer

Moisture Control System

The drier controls as actuated by the Aquatel gage were also designed by the mill to suit their specific requirements. The automatic control function is concerned with only the last eight driers as in Fig. 14. Each pair of lower or upper driers is manually adjusted for the proper differential at its respective Bailey bias-loader at the dry end console (Fig. 15). Then the Aquatel is superimposed on all eight simultaneously. Since the machine does not operate to its limit of its drying capacity as yet, these driers are presently operating at around 8 to 10-lb. of steam pressure.

Should a break occur on the paper machine, then the Aquatel system is automatically switched to manual control and a three-way solenoid valve in the signal line by-passes the normal control set point to an additional bias-loader giving a lower set point on the steam pressure control system to prevent overheating. When the web is back in place, then the original bias setting is returned and the Aquatel is put back on automatic control. The measuring systems are removed from the web at the time of break and go back on automatically after the web is returned with the signal being supplied by a photoelectric cell and light source located at the reel.

Information

Both the Aquatel and beta gage scan the entire web continuously with the forward scan at 120 f.p.m. and the retraction scan at 480 f.p.m. In order to separate the "across machine" profiles from the integrated averages, each measuring system produces two identical output signals which are fed independently into: (1) a long time constant integrating circuit for machine direction average and (2) into a somewhat shorter time signal but adjustable for purposes of X-Y recording of the profile. The Aquatel machine

direction average is presented on a wide strip chart recorder which is precalibrated with a single range of 3 to 8% moisture. At programmed intervals Aquatel profiles are presented on the X-Y recorder.

Similarly the beta gage machine direction average is presented independently on a wide strip chart recorder on one of five direct reading ranges available. Four ranges of 20-lb. per 2880 sq. ft. with a 50% overlap span from 10 to 60-lb. and a fifth range covers from 50 to 100-lb. As with the moisture system, basis weight profiles appear either on demand or at programmed intervals at the X-Y recorder. The Y axis or the sensitivity of the presentation at the X-Y recorder is identical with the direct reading scales as presented on the two individual recorders for the machine direction averages.

With each measurement system is a control unit which operates when either the basis weight or moisture records deviate from the specification setting. Each time a control is initiated, a marginal pen is actuated recording a short stroke on the right hand margin of the chart. This record allows an evaluation of the frequency of controls and may possibly lead to the elimination of cyclic behaviors on the paper machine.

The measurement signals from both gages are electrical and recorded as millivoltage; however, the control signals as indicated in Figs. 13 and 14 are pneumatic. This electrical to pneumatic transition is affected by a special transducer unit which consists of a reversible electric motor geared to a pneumatic reducing valve on a 3 to 15-lb. air line (Fig. 16). The direction of control and the amount of the control is preselected at the machine direction average recorder and a time pulse proportional to deviation from the specification point is fed into the reversible electric motor, such as to vary the air pressure at the needle valve. Both control systems have the conventional fail-safe error safeties which monitor the time in seconds of control, the deviation from the specification point and the position of the control valve. Should an excessive amount of control be required, if the recording go outside the control band or the control valve reach the end of its travel, the control systems are automatically switched to manual.

Results of the Combination System

In any control system, it is of primary importance that good measurements be made and in turn these measurements are a function of calibration.

The beta gage system was supplied as a precalibrated measurement system and was checked after startup by conventional methods of weighing out samples taking into account moisture and checking against the recorded basis weight record. In order to better assess the average basis weight record, 12 sheets were taken across the reel and 60 samples, 12 by 24 in., were measured and averaged. Over a course of 6 weeks with extensive samplings such as this, the basis weight record was found to be within the stated accuracy of ±0.5-lb. or 1% of the basis weight, whichever was greater. The functioning of the automatic control is illustrated by the sample of basis weight chart (Fig. 17) with the specification of 31.5-lb. maintained within ±0.5-lb.

Accurate calibration of the "on the machine"

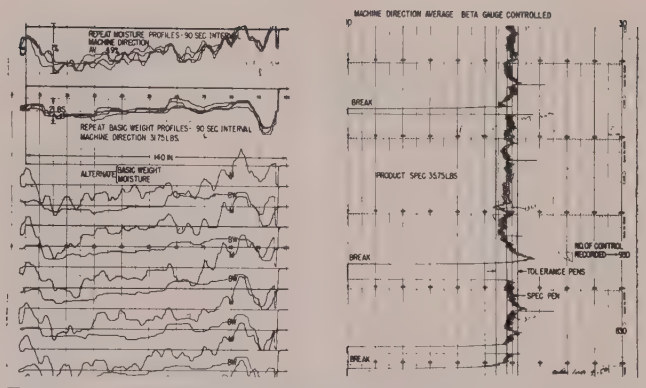

REPEAT MOISTURE PROFILES 90 SEC INTERVAL
REPEAT BASIC WEIGHT PROFILES 90 SEC INTERVAL
MACHINE DIRECTION 31.75 LBS
ALTERNATE BASIC WEIGHT MOISTURE
MACHINE DIRECTION AVERAGE BETA GAUGE CONTROLLED
BREAK
PRODUCT SPEC 35.75 LBS
NO. OF CONTROL RECORDED
TOLERANCE PENS
SPEC PEN

Fig. 17. Machine direction basis weight record and BW—% moisture profiles

Aquatel system was accomplished by first calibrating a laboratory unit and then transferring the information of settings and span to the "on the machine" unit. The accuracy of the over-all system was checked on by means of samples from reels similar to that on the beta gage unit. Twelve sheets across the web were rolled up and placed in a container, weighed, and dried, and the per cent moisture result compared to the machine direction average record. Over the period of 6 weeks through which an accuracy evaluation was carried out, over 85% of the samples fell within ±0.4% of the recorded Aquatel measurement. Figure 18 illustrates manual and automatic control of moisture with automatic control maintaining the moisture within ±0.3 of 1% of the specification point.

Profile information is presented at the X-Y recorder at programmed intervals with the record alternated between basis weight and moisture (Fig. 17). Difficulty in interpretation may arise when the alternating records overlap and in such a situation, either the spacing may be increased or the consecutive records superimposed with zero chart advance. The sensitivity of the X-Y record is identical with the machine direction recorders. Thus a 1-in. displacement on the Y axis represents 2-lb basis weight and 1% moisture.

The dip in the front side of the basis weight profile was most disconcerting to the operating personnel as it could not be eliminated by slice adjustment; however, it has been tied to a stock bleeding system on either side of the box and has been removed by more careful adjustment of this variable.

It is of interest to note that this mill is presently investigating their new Valley headbox, considering in detail the effects of changing the headbox inlet manifold flow pattern. Such a study would be extremely time-consuming without the scanning gages and X-Y presentation and in all likelihood, not ever attempted. An enormous amount of knowledge is

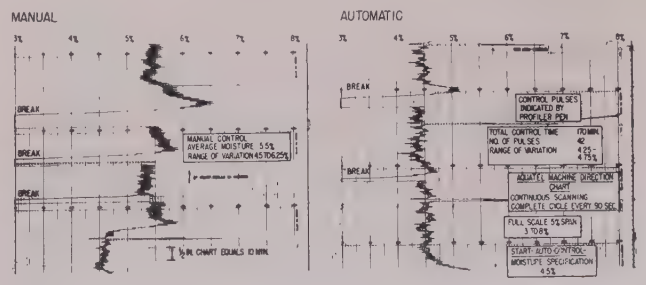


Fig. 18. Manual vs. automatic control with the Aquatel

yet to be gained from the practical operating experience on the paper machine combined with the unique source of information. As it has been reported many times before, it is unrealistic to expect the optimum in good control of the papermaking process merely by hanging measurement and control equipment on the existing paper machine and it is anticipated that by combining skills of the papermaker with the process control supplier that much better systems will evolve.

FUTURE SYSTEMS

As more and more confidence is gained in the equipment and its application in the industry becomes more widespread, paper machines and the accessory equipment will be designed with the gaging systems included in the original unit. Indicative of this trend is a recent gaging system designed for a paper machine which incorporates three machine coating operations. In particular with machine coatings, such as trailing blade coaters, it is not feasible to grab samples ahead of the coater and thus the amount of coating weight can be in doubt. By means of scanning beta gages and moisture gages, measurements are to be made on the base stock before the first coating between the first and second

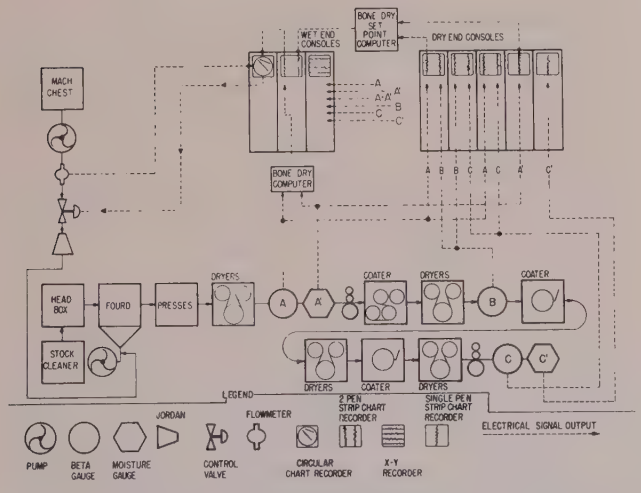


Fig. 19. Schematic of multigage installation designed for St. Francisville Paper Co.

coater and after the final coating at the reel. A schematic diagram illustrates the layout of the gaging equipment on the paper machine and also demonstrates the utilization of the moisture-free measurement for both automatic control via the setting of the Foxboro flow meter set point and the use of the X-Y recorder for presenting profiles for all the measuring systems on the paper machine.

In addition to the multigaging systems which are proposed for coating measurement, other units may be profitably added to the paper machine instrumentation picture. As previously mentioned, wet end gages are of increasing interest because they can be associated with the per cent fiber from the dry-end combination to give the per cent moisture entering the drier system. After each section of driers, a beta gage couple (front side and back side) may be added to give moisture content progressively down the drier system.

New equipment includes the PermaWeb wet-end break arrestor system which senses a break at the wet end and immediately cuts a tail on the appropriate side to prevent having to re-thread. The tail is then automatically widened by a moving jet at the couch to restore the paper machine to full production.

New electronic draw speed equipment provides accurate measurement and recording of linear speed and draw between the couch, presses, and the driers. Thus a means is provided for studying effects of draw on paper quality and machine efficiency.

As was previously mentioned, with the profile information available and increasing emphasis on the abilities to set the slice accurately, spindles will have individual micrometer readouts and motorized controls will be added to the slice enabling individual adjustments to be made against a known pattern for specific grade of paper. The next obvious step then is to completely automate the slice by means of tying together the mechanical controls and the process measurement instrumentation.

This not too futuristic paper machine instrumentation layout is illustrated in Fig. 19. Included is a step in the direction of digital readout and production analysis. This implies that with more instrumentation and the same or fewer "eyes," data readout becomes more necessary for information and "action decisions."

Of course, digitized information becomes equally available to all areas of the mill, suitably modified for a specific purpose. Thus quality control. production, accounting, and management groups may share in the "information presented."

In conclusion, the comments by J. Franklin of Bowaters (*19*), made two years ago, are still valid. "Before papermaking can be termed a truly automatic process, therefore, this challenge must be met—each step on the machine must be measurable and controlled; not only longitudinally, but laterally. In this field the papermaker and the process control engineer meet in designing an exciting future."

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Modification of Coating Colors with Amines

A. W. CLAXTON

The addition of small amounts of certain amines or amine salts to clay-water slurries or to starch coating colors has a profound effect upon their rheological properties. Hagan rheograms of clay-water slurries containing varying quantities of diethylenetriamine illustrate an extreme degree of dilatancy, dependent upon the amount of amine used. A theory is offered to explain the action of amines; a joining together of individual clay particles edge to edge to result in an effective increase in diameter-to-thickness ratio. The extreme dilatancy exhibited in high solids slurries when polyamines were added was not evident in the starch coating colors studied. Instead, the coating colors show increased thixotropy. Leveling index was increased from 0.299 to 0.413 in one case by use of 0.20% ethylenediamine. Paper coated with colors containing amines show a significantly higher gloss, easier finishing, and smoother printing surface than control coatings without amines. Evaluation of coating colors with the roll-inclined plane equipment indicates that coating color solids can be reduced with little or no adverse effect upon areal ratio (a measure of the fluid migration properties of the coating color) and with accompanying improvement in gloss and printing smoothness.

RESEARCH involving the addition of very small amounts of certain amines to clay-water slurries and to coating colors has shown that the amines have a profound effect upon rheological properties. Initial results have indicated some highly beneficial effects on printability of the resultant coated paper. Time has not yet permitted complete exploration of this discovery, but the results to date may create enough interest so that others will wish to study this phenomenon. It seems possible that it may have significant meaning to the coating industry.

One of the more important reasons for coating a sheet of paper is to make it smoother. Two of the principal factors that affect smoothness of the coated sheet are (1) rheological properties of the coating color, which determine the manner in which the coating is applied, and (2) orientation of pigment particles to present a more or less continuous pigment surface on the surface of the paper. It is known that amines affect flow properties—this is relatively easy to measure. It is suspected that they have an effect upon the ultimate pigment surface. The effect of amines upon flow properties of pigment systems will be discussed initially.

Figure 1 shows Hagan rheograms of two identical 67% solids clay-water slurries, with the exception that the slurry on the right contained 0.10% diethylenetriamine on the weight of the clay. This is an excellent example of extreme dilatancy. (To conform to the more familiar shear rate/shearing stress rheogram and to make for easier comparison, the circular rheograms obtained with the Hagan viscometer have been transposed to the more conventional type that can be shown on a rectilinear graph.)

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It is doubtful that increasing dilatancy of clay-water slurries, per se, has easily recognizable value to the coating industry. On the contrary, a great deal of effort has been expended in seeking ways to reduce the dilatancy of clay slurries. This action has, however, been very useful in studying the effect of various amines, since the effect shown in clay slurries can be related to the effect on coating colors, and it is much easier and less time consuming to make clay slurries than it is to make coating colors.

TYPES OF AMINES EFFECTIVE

There are, of course, a wide variety of chemical compounds that may be classed as amines. Not all of these, by any means, have been found to be effective. In fact, only those compounds that have at least *two* functional amine groups are known to be effective. These include ethylenediamine, diethylenetriamine, triethylenetetramine, tetraethylenepentamine, and triethylenediamine. Certain other amines, such as dimethylaminopropylamine and diethylaminopropylamine, are also effective. In Fig. 2 the structural formula for some of these polyamines is shown. Formulas for ethylenediamine, diethylenetriamine, triethylenediamine, and dimethylaminopropylamine are illustrated. For lack of space, triethylenetetramine and tetraethylenepentamine, which would naturally follow

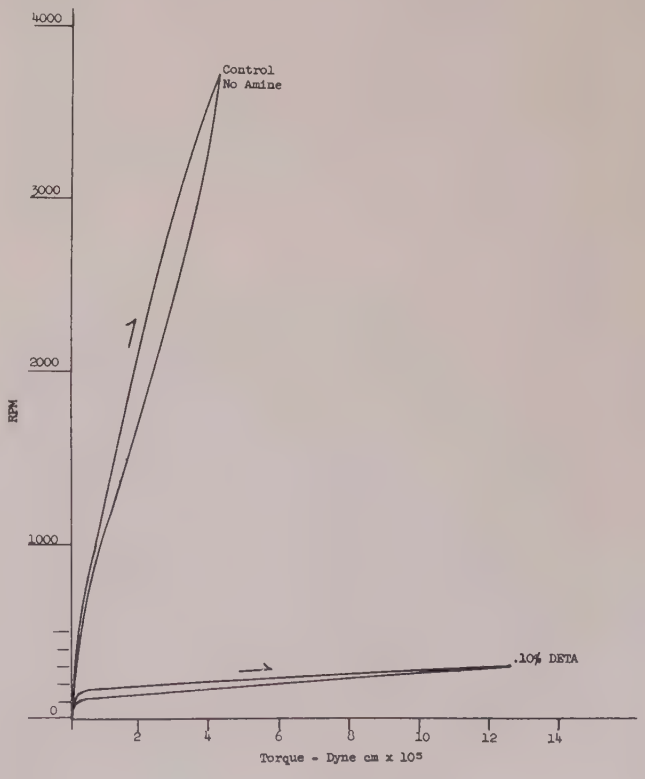

Fig. 1. Effect of diethylenetriamine on flow properties on clay-H_2O slurries-67% solids

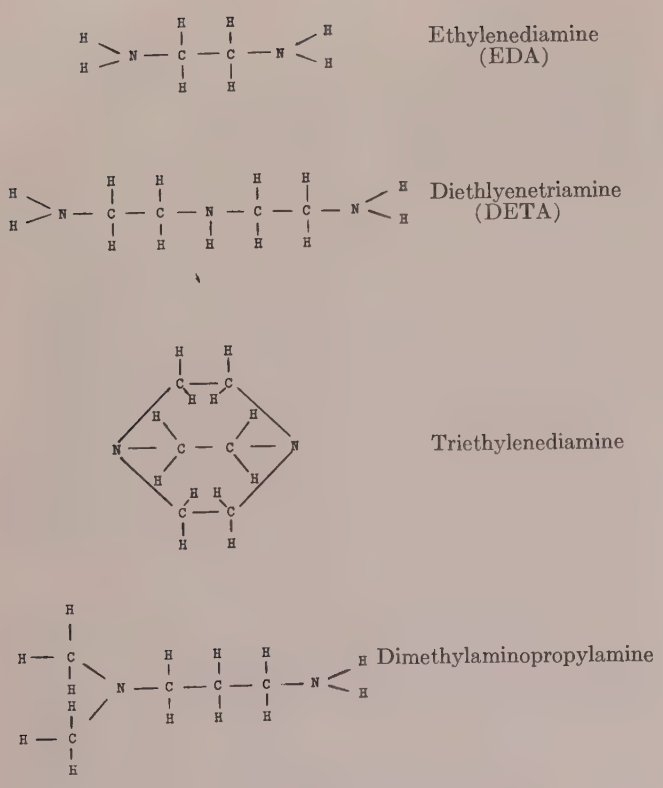

Fig. 2. Structural formulas of amines

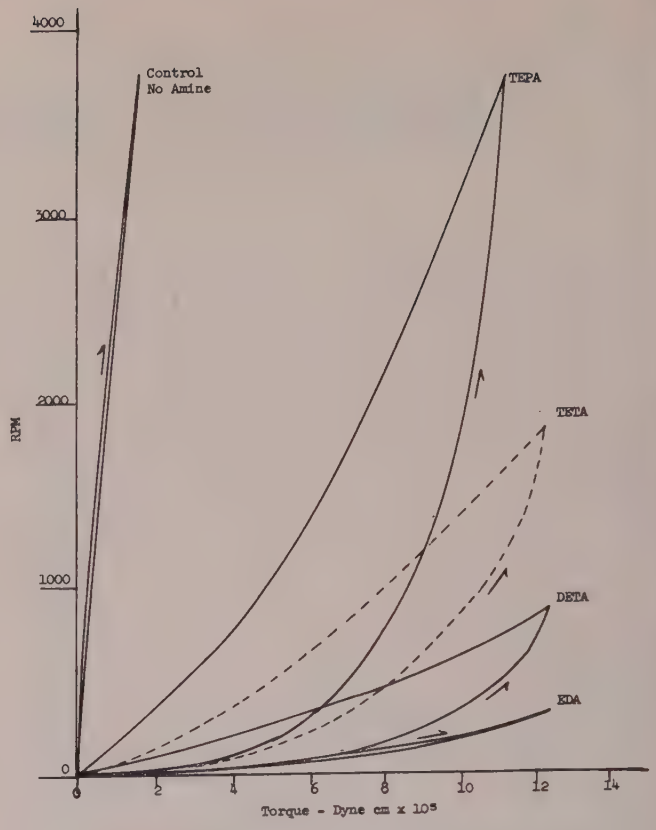

Fig. 3. Effect of 0.05% amines on flow properties of clay-H_2O slurries-60% solids

diethylenetriamine in chain length and number of amine groups, have been omitted from this illustration. Frequent use is made in this paper of the abbreviations shown. Diethylenetriamine, which was used most frequently in this work, has become known as DETA.

Although the structural forms of the amines shown here differ somewhat, the significant point is that they all have at least *two* functional amine groups. Amines not having this characteristic have been found to be ineffective. A compound made by neutralizing *one* of the amine groups on the end, by treatment with the right amount of acetic acid, is also effective, probably because the compound reverts to its original form when placed in water. Such a compound has become known as a half-acetate.

Significance of pH

Since the amines are alkaline in nature and have different ionization constants, it has been necessary to control pH in comparing the action of the various products. At any given pH, it was found that the shorter the chain length, the more effective was the amine. For example, ethylenediamine was more effective than, say, tetraethylenepentamine. This is shown in Fig. 3. Here, 0.05% of each of the amines was added to 60% solids clay slurries, with pH controlled at 6.0. The Hagan rheograms illustrate that ethylenediamine, the bottom curve in the illustration, caused severe dilatancy and was more effective than tetraethylenepentamine. This greater effect of the short-chain length amine is probably related to its higher ionization constant. It might be pointed out here that the 60% solids slurries and the amine additions at the 0.05% level were selected so as to better illustrate the differences between the various amines. Had 67% solids slurries been used, for example, or, if a greater quantity of amine had been added to the slurries, all the rheograms would have shown extreme dilatancy, much as that shown in Fig. 1, and one would have been less able to differentiate between them. The quantity of amines used here was not, except in the case of ethylenediamine, sufficient to cause dilatancy at the particular solids level. Actually, these rheograms are quite similar to those one might expect if rheograms were obtained on incompletely dispersed clay slurries at increasing solids content from left to right. Again, the significant point is that ethylenediamine, with its high ionization constant, was the most effective.

While the greater activity of ethylenediamine might indicate its selection as the best amine to use, its higher volatility makes it somewhat less desirable than the less volatile, though less effective, longer-chain compounds.

THEORY OF ACTION

It might be well to digress a moment and theorize on the mechanism by which these amines cause this severe dilatancy. While it has not been conclusively proved, the following explanation may be logical. It is well recognized that the *shape* of clay particles has a profound effect upon their rheological characteristics. It is also known that clays in which the diameter-to-thickness ratio is large tend to exhibit more dilatancy under specified conditions as to solids content, etc., than do clays having a relatively smaller diameter-to-thickness ratio. Because of the drastic change in rheology brought about by the amines, it would seem quite likely that, in some manner, the size or shape of the individual particles has been altered.

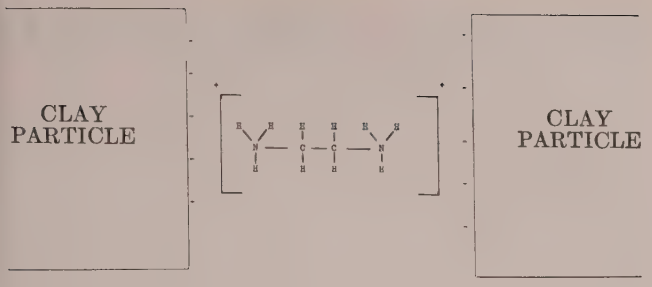

Fig. 4. Clay-amine-clay linkage

How could amines do this? Through the years clays have generally been thought of as being chemically inert. This is not absolutely true, however, and in recent years clay technologists have come to regard clays as being capable of undergoing chemical reactions. Clay particles have a net negative charge. Asdell (*1*) and others have taught us that these negative charges are concentrated along the particle edges. After ionization in aqueous media, amines, such as diethylenetriamine, have a net positive charge. The presence of clay particles with negative charges and amine molecules with positive charges paves the way for a chemical union. The fact that only those amines having two or more active amine groups are effective, leads to the possibility that the two amine groups in some way react with active chemical sites on clay particles.

As illustrated in Fig. 4, it would appear logical that the amine chain structure has acted as a bridge or link between clay particles, joining two particles together rather strongly. Such a linkage would be similar to that created between clay particles and cellulose fibers by aluminum ions when alum is used with filler clays. If this is valid, then it can be concluded that the effective diameter-to-thickness ratio of the particles has been increased. This theory would seem to fit very nicely with the effect of amines in increasing the dilatancy of clay-water slurries.

So far this is theory. Proof that this is actually what happens has not yet been developed. Particle size of clays treated with amines has been determined using the conventional gravity settling techniques, but no difference was noted in size resulting from the amine treatment. Very probably the necessary dispersing and physical action required in this procedure has broken down the clay-amine-clay linkages. Efforts, using x-ray diffraction techniques, to delineate differences in particle orientation on the surfaces of paper coated with coating colors containing amines have so far resulted in little encouragement. Further evidence to support the theory of particle linkage, however, will be discussed later.

Table I. Effect of Ethylenediamine on Rheology of Starch Coating Colors

	Control-no amine	*EDA 0.20%*
Apparent viscosity at 3733 r.p.m., poises	1.55	2.13
Coefficient of thixotropic breakdown	0.582	0.975
Yield value, dynes per sq. cm.	1368	1368
Leveling index	0.376	0.457

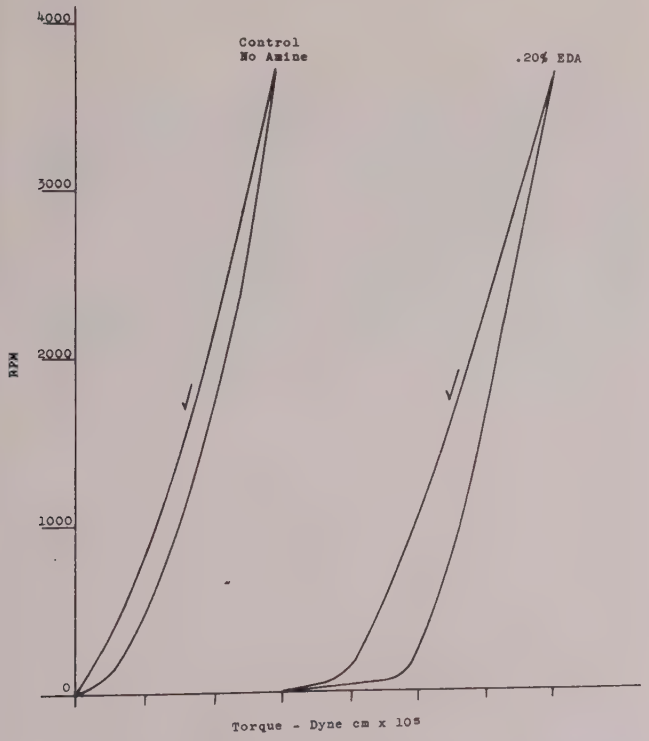

Fig. 5. Effect of ethylenediamine on rheology of starch coating colors

RHEOLOGY OF COATING COLORS

As mentioned previously, dilatancy in a clay-water slurry is not generally desired in coating mills. It is especially interesting, however, that dilatancy shown in clay slurries is not evident as such in the coating colors investigated so far. On the contrary, starch coating colors in the neighborhood of 50% solids exhibit a high yield value, increased thixotropy, and a higher leveling index when amines are added. In Fig. 5 are shown rheograms of 50% solids coating colors containing 18% starch, which are identical with the exception that one

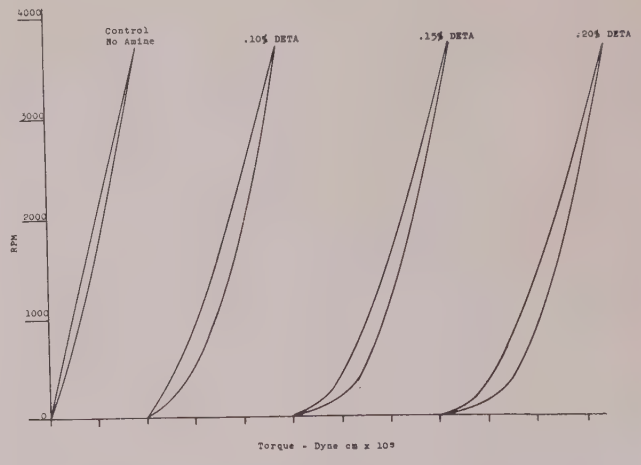

Fig. 6. Effect of increasing amounts of diethylenetriamine (DETA) on rheology of coating colors

Table II. Effect of Increasing Amounts of Diethylenetriamine on Rheology of Coating Colors

	Control-no amine	DETA 0.10%	DETA 0.15%	DETA 0.20%
Apparent viscosity at 3733 r.p.m., poises	1.79	2.05	2.24	2.16
Coefficient of thixotropic breakdown	0.553	1.092	0.951	0.984
Yield value, dynes per sq. cm.	912	2280	4104	4788
Leveling index	0.298	0.426	0.442	0.506

color contains 0.2% ethylenediamine on the weight of the clay pigment. It will be noticed that this color has a much higher yield value and is substantially more thixotropic than the control color containing no amine. On these rheograms the numbers on the torque axis have been omitted so as to avoid confusion. All the rheograms do start from the zero point on the torque axis.

Table I shows data on yield value, coefficient of thixotropy, apparent viscosity, and leveling index for the two rheograms just shown. Addition of the amine increased the apparent viscosity from 1.55 to 2.13 poises. Coefficient of thixotropic breakdown was almost doubled, indicating a substantial increase in thixotropy. Yield value, a term used to indicate the amount of force required to achieve more or less equilibrium flow, was greatly increased, and leveling index was increased from 0.376 for the control to 0.457 for the color containing ethylenediamine.

Figure 6 shows rheograms of coating colors containing 0.1%, 0.15%, and 0.20% diethylenetriamine on the weight of the clay pigments, together with a control color containing no amine. Again these are 50% solids colors containing 18% starch. The increase in thixotropy and area of hysteresis loop is quite evident in the case of those colors containing amines. A breakdown of values obtained from these rheograms is shown in Table II. Comparing the control color with that containing 0.10% DETA, it can be seen that the amine has caused an increase in viscosity and a substantial increase in thixotropy, yield value, and leveling index.

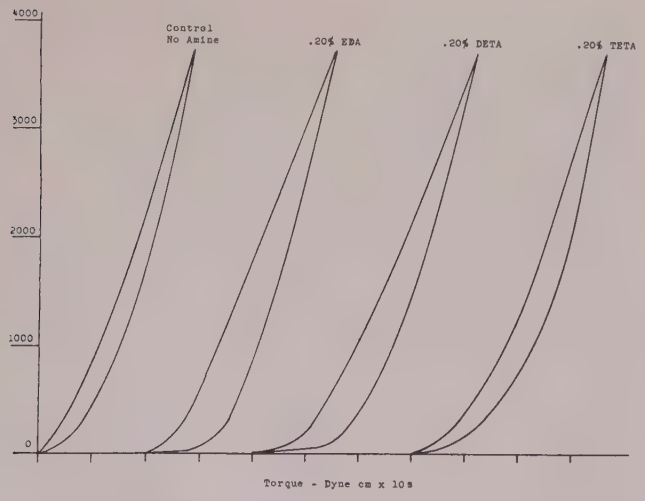

Fig. 7. Effect of various amines on rheology of coating colors

Table III. Effect of Various Amines on Rheology of Coating Colors

	Control-no amine	EDA 0.20%	DETA 0.20%	TETA 0.20%
Apparent viscosity at 3733 r.p.m., poises	1.55	1.89	2.00	1.89
Coefficient of thixotropic breakdown	0.610	1.003	1.045	0.805
Yield value, dynes per sq. cm.	2508	4104	5106	4332
Leveling index	0.393	0.531	0.523	0.426

With the exception of the apparently anomalous values for viscosity and coefficient of thixotropic breakdown, increasing the amount of DETA has a cumulative effect.

Figure 7 shows rheograms of starch colors containing 0.20% of various amines, with pH controlled at 8. This will provide a comparison of the effects of the several amines, similar to that shown in the case of the clay-water slurries. It is evident that ethylenediamine has a greater effect on flow properties than either diethylenetriamine or triethylenetetramine, both longer-chain amines with lower ionization constants.

Table III is a breakdown of rheological values obtained from these rheograms. In particular, attention is directed to the values for leveling index. The control color, with no amine, had an index of 0.393, the EDA color had an index of 0.531, and the DETA color and the TETA color had leveling indices of 0.523 and 0.426, respectively. The rheograms shown for these coating colors containing amines exhibit no evidence of dilatancy.

It might be well to mention further evaluation of coating colors with the roll inclined-plane viscometer. For those who may not be familiar with this instrument, a brief description might be in order. Developed originally by K. A. Arnold (*2*) and studied further by G. A. Hemstock and J. W. Swanson (*3*), the device was designed for studying flow properties of coating colors and other systems under conditions of shear more closely approaching those found in commercial practice than is the case with the conventional rotational viscometers available. A very accurately measured quantity of coating color is placed upon a selected spot on an inclined glass plane. A smoothly surfaced roll is allowed to roll down the incline over the drop of coating color. By measuring the spread area of the tear drop pattern after passage of the roll,

Table IV. Effect of Amines on Areal Ratio of Starch Coating Colors

No.	Diethylenetriamine (DETA), %	Areal ratio	Viscosity poises at 80 cm/sec
1	Control–no DETA	2.01	0.67
2	0.05	1.98	0.67
3	0.10	1.94	0.81
4	0.15	1.91	0.99
5	0.20	1.86	1.26
6	0.25	1.81	1.40
7	0.30	1.74	1.62

a value for film thickness can be determined. By relating this to the speed of the roll and the roll weight, values for viscosity in terms of poises can be calculated.

While rolls of different weights and surface constructions may be used, in these studies a steel roll 4 in. in diameter, weighing 5.850 g. and traveling at a speed of 80 cm. per sec. at the time of impact with the drop of coating color was used.

Effect on Areal Ratio

Hemstock and Swanson have used areal ratio to obtain information relative to the performance of

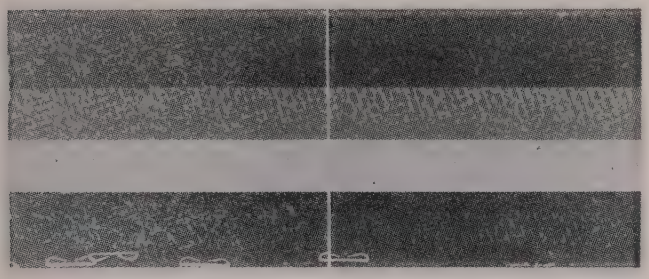

Fig. 8. Effect of diethylenetriamine on printing properties

coatings immediately after application. Areal ratio is defined as "the ratio of the spread area created by a bare steel roll and that created by a roll wrapped with raw stock and rolled over the drop at the same speed." More specifically, this value is related to what happens to the fluid and solid phases of the coating after application and how this affects printing smoothness. By using such a ratio value, the viscosity of the material being evaluated is removed from consideration.

Areal ratio is believed to provide a measure of the fluid penetration characteristics of the coating color.

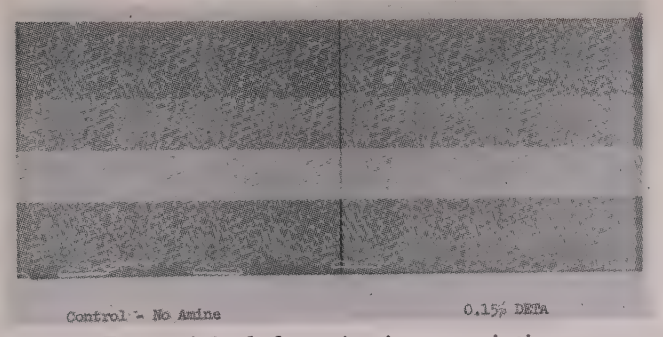

Fig. 9. Effect of diethylenetriamine on printing properties clean-up sheet

It is felt that this value much more nearly simulates conditions on the coating machine than do tests in which raw stock specimens are floated on the surface of the colors as is done in the test for water release. An areal ratio of unity would indicate neither fluid penetration nor paper surface roughness. The closer the values approach unity, the slower would be the fluid release from the coating color. Within certain limitations, a low value for areal ratio would be desirable in at least certain applications since this would provide a longer period of time for orientation of clay particles.

Table IV shows values for areal ratio and viscosity of 50% solids starch coating colors containing diethylenetriamine in amounts varying from no amine in the control coating to 0.30% diethylenetriamine in coating color No. 7. Areal ratio steadily decreased from 2.01 for the control to 1.74 for coating color No. 7, which contains 0.30% diethylenetriamine. At the same time an increase in viscosity is noted. These figures indicate that the effect of amines is cumulative with respect to areal ratio and viscosity.

In some cases, for example, in applying lightweight coatings, it has been rather firmly demonstrated that coating colors having a relatively low areal ratio result in smoother printing surfaces. Areal ratio may be reduced by increasing solids content of the coating color. This sometimes presents complications, however, particularly as to coat weight control. The use of amines provides an opportunity to decrease areal ratio without resorting to an increase in solids content.

Effect on Printing Surface

Perhaps more significant than any feature yet mentioned is the improvement in surface properties of paper coated with colors containing amines. Most of

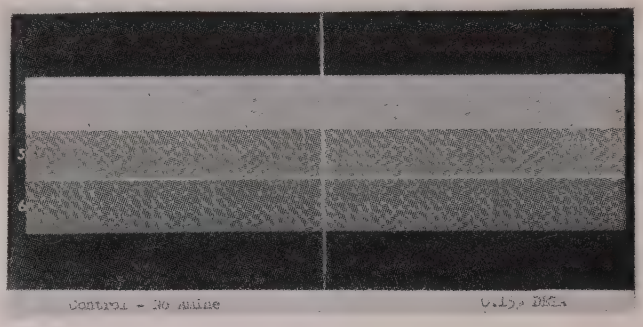

Fig. 10. Effect of diethylenetriamine on printing properties

the work has been done with starch coating colors in the neighborhood of 50% solids applied with a pilot plant model transfer roll coater to lightweight publication-grade raw stock. When using 0.10 to 0.20% diethylenetriamine, on the weight of the clay, an improvement of about 10% in gloss was obtained, opacity was increased 2 points, and brightness was increased by 1 to 2 points. Surprisingly, adhesive demand is increased when amines are used, causing, in the case of the lightweight papers mentioned, a lowering of adhesive strength by about one wax.

Paper coated with the roll coater was printed on a letterpress proofpress. Figure 8 shows a photograph of two samples in which the coatings were identical with the exception that the sample on the right contained 0.15% diethylenetriamine. Improvement in continuity of ink surface, clarity, and absence of mottling will be noted in the surface containing the diethylenetriamine. Figure 9 is a photograph of a cleanup sheet printed immediately after those shown in Fig. 8. Since the surface printed on that portion of the plate

on which the amine-containing sheet was printed obviously picked up less ink, it may be concluded that the amine sheet picked up more ink than the control sheet. While this may be true, the ink appeared to stay on the surface better, or at least the ink pigments did. Reflectance values, obtained with a Bausch & Lomb opacimeter, on the reverse side of the printed sheets were 74 for the control versus 78 for the amine-coated. The values reflect less show-through of ink for the amine coating even though this paper apparently picked up more ink.

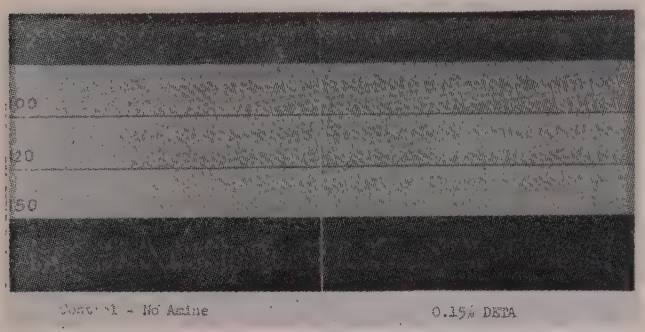

Fig. 15. Effect of diethylenetriamine on printing properties

Samples of paper coated in the manner previously described were printed on a different model proofpress. Figure 10 is a photograph of the printed samples. Again, the improved crispness and continuity of the inked surface of the sample on the right, which was coated with a color containing 0.15% DETA can be seen. Note particularly the absence of mottling in the 40% (No. 4) half-tone area compared with the same area of the control sample. This is due to more perfect contact of the half-tone dots which results in a more even reproduction of the impression.

Figure 11 shows a photograph of coated paper that was printed with a different printing plate. Improvements of the nature previously illustrated are again evident.

In the case of each of the printed paper comparisons shown, both the control sample and the sample containing DETA were printed at the same time on either half of the printing plate. Check printings were made by reversing the respective positions of the samples and the results were no different from those shown.

In Fig. 12, an attempt has been made to show the effect of varying amounts of DETA on printing properties. Again the various samples shown were coated on the pilot-scale coater and printed on a proofpress. The control coating with no DETA appears at the top. Adjacent to the control is the sample coated with a color containing 0.10% DETA. The improvement in printability is evident. Even the sample containing 0.05% DETA shows improvement over the control sample.

What is the mechanism that results in the printing improvements just shown? The theory advanced earlier that the amines act as a bridging link between clay particles, thus effectively increasing the diameter-to-thickness ratio of the clay particles, may be valid. If this be the case, the "larger" plane surfaces of the clay particles might well produce a smoother surface having superior orientation. This would be expected to result in a better print job.

Experience in "surface treating" of clays teaches that when a clay is treated with an amine, the clay becomes organophilic, that is, it becomes more susceptible to wetting by organic liquids.

The use of amines in coated paper may serve to increase the wettability of the surface by the ink vehicle. The vehicle may penetrate faster and more evenly, leaving the ink pigments closer to the surface. This may explain why less show-through with more ink

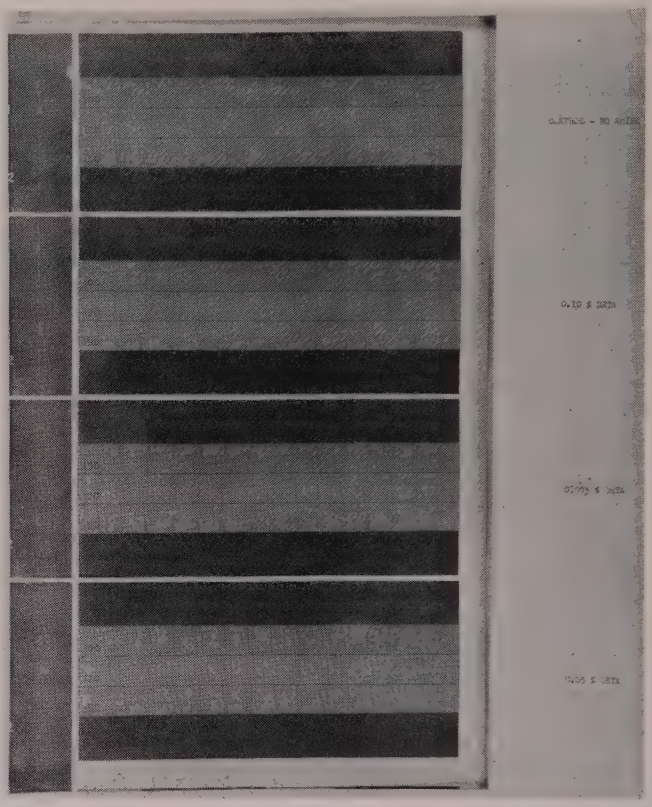

Fig. 16. Effect of increasing amounts of diethylenetriamine on printing properties

on the printed samples as shown in Fig. 12, was obtained. However, preliminary tests for penetration of the ink vehicle in which a drop is placed on the coated surface have not substantiated the theory that the vehicle penetrates more rapidly, although in these tests a decided difference was noted in the manner of vehicle penetration. In the case of the coatings containing amines, the vehicle spread and penetrated much more evenly and with much less mottling than in the case of the control coatings. This is an area that certainly needs additional study.

There would then seem to be at least three possible factors in the improvements noted: (1) a change in rheology that has resulted in improved application of the coating; (2) an increase in effective diameter-to-thickness ratio of the clay particles which results in superior pigment particle orientation producing, in turn, a smoother surface; and (3) modification of the coating to increase the wettability of the coated surface by the printing ink vehicle which results in more even vehicle penetration. Or, perhaps all three factors play a part. It is hoped that further research will lead to more conclusive answers on these points.

While very little work has been done with amines in low-solids casein coating colors, early indications are that they have no effect upon viscosity, probably because it is not noticeable in low-solids fluid systems. Whether improvements in printing properties in such systems can be obtained, with no change in flow properties, remains to be determined.

The various amines mentioned in this report are supplied in liquid form. They are somewhat toxic and the manufacturer's precautions in handling should be followed. The half-acetates are not believed to be commercially available.

The amines are effective when added to either the clay-water slurry or to the coating color. The same amount appears to be slightly more effective when added to clay slurries than when added to coating colors, but in many applications this would present a problem due to the dilatancy created in the clay slurry. When added to either slurry or color, they should be diluted quite a bit before use to forestall localized action and the formation of agglomerates that would be difficult to break down.

CONCLUSIONS

Results obtained to date indicate that polyamines may prove to be a means of altering the rheological properties of coating formulations in such a manner as to significantly improve their application. In addition, it has been demonstrated, at least on a pilot-plant scale, that the proper use of amines will result in substantial improvement in printing qualities of coated paper; namely, higher gloss, increased brightness and opacity, better ink coverage, fidelity of halftones, and decreased mottling. Further and more intensive investigation of this sub ect would seem to be well justified.

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Turbine Aeration and Other Methods for Re-aerating Streams

AVERILL J. WILEY and BERNARD F. LUECK

Commercial application of practical processes for introducing oxygen into rivers and other receiving waters low in dissolved oxygen content has been a comparatively recent development for consideration by industrial engineers concerned with stream pollution. Deoxygenation of river waters in areas downstream from centers of increased population and industrialization is a growing problem which has become critical on many streams. Reaeration by artificial or mechanical methods was suggested as being a theoretically feasible operation at least 20 years ago, but years of testing and evaluation were required to develop practical methods. Turbine aeration at power dams is one of the first methods which has reached the stage of being used extensively. Several power dams on each of three Wisconsin rivers have been equipped and operated commercially during the past three years and other installations have proved successful elsewhere. It may be assumed from this experience that, where suitable conditions exist along a stream, reaeration may not only be desirable but eventually may be required as standard practice for good stream sanitation and for the promotion of self-purification processes in river waters during critical periods of low dissolved oxygen levels. Basic principles for achieving effective and efficient aeration at reasonable cost are becoming fairly well established, but methods to be used will in all probability be greatly improved with further study and development. Much remains to be learned about ways in which to evaluate the practical results obtained for introducing oxygen into large bodies of flowing water where numerous variables prevent easy application of theoretical formulas which have been advanced over the years for purposes of engineering design and evaluation. Aeration accomplished over dam spillways and weirs and through canal gateways can, where favorable conditions exist, be an effective method of achieving substantial degrees of reaeration, and should receive additional study and evaluation. Forced air diffusion, spray aeration, and other methods of mechanical aeration have been studied and may eventually be important ways for achieving stream reaeration. Methods and results for different types of aeration are reviewed showing that oxygen may be introduced at efficiencies on the order of 25 to 45% absorption of the oxygen from air introduced by mechanical methods and at costs as low as $3 to $20 per ton of oxygen actually absorbed. Problems requiring further study are outlined. It is suggested that professional engineering groups in the fields allied to water pollution problems might do well to establish a task group to assemble and disseminate authoritative data now much needed for purpose of proper engineering design of stream reaeration facilities.

Oxygen in large quantities is required to maintain natural processes of self-purification in all bodies of water receiving natural and man-made wastes. More and more, it is becoming desirable to promote and maintain these processes of self-purification and additional sources of oxygen often are needed. There are many end uses for oxygen based upon various chemical and biochemical reactions occurring in the waters of lakes, streams, and the oceans. This discussion will be primarily concerned with methods of

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introducing oxygen to rivers flowing through or beyond populated and industrialized areas where comparatively short 10 to 50-mile stretches of a stream become seriously deficient in oxygen after receiving effluent discharges having a substantial oxygen demand. Stream studies have shown that critical areas on rivers flowing at 1000 to 2000 c.f.s. may at times have demands as high as 100 tons or even 1000 tons of oxygen per day (*1*, *2*). Fortunately, substantial portions or even all of the oxygen required to meet these large requirements for oxygen are normally made available to the water from a variety of natural aeration sources. It is for those occasions where a deficit in oxygen supply develops that it becomes of practical interest to devise artificial means for introducing oxygen to the water to alleviate or prevent the development of the critically deaerated stream conditions which have become widely recognized as typical of stream pollution involving nontoxic oxidizable matter.

Stream re-aeration becomes a more practical operation for consideration when it is understood that the objective usually is based upon maintaining a desired practical level of dissolved oxygen in the water by adding sufficient amounts to make up the critical portion of the deficit between total demand and the amount of oxygen available from natural sources.

The lower Fox River in Wisconsin, a 29-mile stretch of stream between Lake Winnebago and Green Bay, has been found (*1*) to have a total loading of as much as several hundred tons of ultimate oxygen demand, but natural sources of aeration can supply the necessary amounts of oxygen for all but short stretches of the total length of the stream during brief periods of high temperature and low water in midsummer and perhaps also under extreme conditions of ice cover in midwinter. For one summer season, calculations showed a daily deficit below the critical level of dissolved oxygen amounting to 38 tons of oxygen in 1956 (*3*). Tests of turbine reaeration were started in 1957 with results sufficiently promising to justify full-scale, continuous operation during the critical summer season on one turbine at each of three power dams in 1958. More turbines at these three dams were equipped for aeration in 1959 and an additional turbine was being tried at a fourth dam in 1959. Results are not fully collated at the time of preparing this paper, but at least 8 tons of oxygen were being added daily to the waters of the Lower Fox during critical periods of low dissolved oxygen during July and August, 1959. These installations all were operating at reasonable cost, and with noticeable improvement in stream conditions even when operating substantially short of meeting the critical deficit calculated in the 1956 studies for the stream. Further improvement in turbine aeration efficiency and expansion of these and possibly other power dam installations can be expected to give further aid in reducing the oxygen deficit in the Lower Fox River. Similar results are indicated from operation of turbine aeration along the Wisconsin and Flambeau Rivers during 1957 (*4*), 1958 (*5*), and 1959, and also in reports from Wagner's work in Germany during 1958 (*6*).

Although the primary cause for deoxygenation of stream results from placing an excess of oxygen demand upon the available supplies of dissolved oxygen in the water, the situation is greatly complicated and accentuated by substantial decrease, or even elimination of important sources for natural re-aeration following construction of hydroelectric power dams, flood control, navigation, and water storage facilities along the lengths of our hard working rivers and streams. The steadily increasing growth of populations and of industrialization thus contribute to deoxygenation of a river in two ways: (1) loading the water with oxygen demands in excess of the oxygen supply and (2) decreasing the capabilities for natural reoxygenation of the stream.

In the first instance, we can look forward to increasing need for finding ways to add oxygen to meet the excess of oxygen demand over oxygen supply, and in the second place we can also expect increasing need for finding means to replace the oxygen lost with destruction of natural means for oxygenation. It becomes apparent that wherever means for river re-aeration can be developed and economically applied, the normal demands of good stream sanitation practice will create increasing need and may eventually even require its installation as a means of stream pollution control.

Stream pollution control authorities would indeed look askance at stream re-aeration facilities installed as a substitute for adequate treatment facilities for wastes prior to discharge to rivers, but it is realized that even the best of waste treatment processes will usually have a substantial residual oxygen demand beyond the reach of economic processing by any method yet available. For situations (usually of short duration) where critical stream conditions develop in spite of utilizing the best available processes of treating waste discharges, government and industrial agencies have in recent years come to recognize that artificial means of introducing oxygen to the waters of a stream may become an acceptable and economically practical process for alleviating conditions of low dissolved oxygen which arise from overloading the natural capacity for self-purification in the stream.

BASIC CONDITIONS FOR STREAM AERATION

Two theoretical formulations and a number of practical criteria are available to help in evaluating the possibilities for stream re-aeration and for design of installations on a river. The proper location of re-aeration facilities is governed by two opposing forces affecting the dissolved oxygen in the stream. One of these forces seeks to deoxygenate the water in order to satisfy the oxygen demand. The other force aims to reoxygenate the steam up to a level of dissolved oxygen saturation for the prevailing temperature of the stream and the partial gas pressure of the overlying atmosphere. These two opposed actions were extensively studied on the Ohio River in 1914 and 1915, and later resulted in publication by Streeter and Phelps of the classical formulation of the oxygen sag curve for a stream (*7*). Expressed mathematically, this resultant action may be written in differential form as:

$$dD = K_1L - K_2D$$

in which L represents the momentary oxygen demand and D the oxygen saturation deficiency, both at any time t, and K_1 and K_2 coefficients defining, respectively, the proportionate rates of deoxygenation and re-aera-

tion. Various modifications of this original formulation have been developed and are useful, but will not be reviewed in this paper.

A thorough understanding of the conditions effecting the oxygen sag of a stream is required for proper location of the re-aeration facilities to be installed. Certain practical conditions can be listed as resulting from experience:

1. The point of re-aeration usually will be found to be best located at the point on the stream where the oxygen sag is greatest.
2. The deoxygenation reactions occurring within a stream involve a time factor, and it is necessary to locate re-aeration facilities substantially downstream from the point of effluent discharge to the river.
3. The total amount of oxygen to be introduced is best distributed along a considerable stretch of the stream effected by the deoxygenation reactions occurring over a length of time.
4. Extremes of temperature for the water materially effect the location at which the low point in the oxygen sag curve occurs, and the best point for re-aeration may shift with the season along the length of a stream.

Although an understanding of stream conditions and of the oxygen sag curve are greatly aided by an understanding of the theoretical considerations, the actual location of reaeration facilities must necessarily be based upon various practical considerations concerned with the location of physical facilities, the economics in bringing sources of energy to the point of aeration, and a host of variables which may materially effect each particular situation under consideration. The presence of substances having an immediate chemical oxygen demand, of substances having a prolonged rate of oxygenation, sludge deposits in a stream, rates and variations in stream flow, are among the more important variables which must be taken into consideration in the interpretation and application of the oxygen sag curve and of the actual location for a stream re-aeration facility.

A second theoretical formulation is of value in the actual design and prediction of performance for the equipment to be installed for reaeration of a river. These basic design considerations were formulated by Adeney, as follows (*8*):

$$W = (w_s - w_i)\left[1 - e^{-0.01(T + 36)\frac{A}{V_t}}\right]$$

in which

W = increase in concentration of oxygen at end of t minutes
w_s = concentration of oxygen at saturation
T = temperature in degrees C.
w_i = initial concentration of oxygen
e = base of common log = 2.718
A = area of contact surface in square centimeters
V = volume of water in cubic centimeters

This formulation helps us to understand the amount of oxygen which will be required to achieve desired degrees of reoxygenation required at a particular site. The efficiency for oxygen absorption will be much greater when the temperature of the water is low and when the initial concentration of dissolved oxygen is low. Practical experience for reaeration of river waters has so far indicated that the introduction of oxygen from air will not be economic when the degree of saturation in the water to be aerated is much in excess of 50%. The best results have been obtained when the degree of saturation is less than 40%. For that reason, it is not usually attempted to operate aeration facilities when the dissolved oxygen concentration exceeds 4 p.p.m. under summertime operating conditions with water temperatures above 20°C. Aerators are turned on when the dissolved oxygen drops substantially below that figure and operated to maintain dissolved oxygens approaching 4 p.p.m. At lower water temperatures, higher levels of dissolved oxygen can be reached and maintained if desired.

The criteria for proper design of reaeration facilities are concerned with the manner in which the oxygen is introduced into the water (especially where oxygen is derived from air). It is essential that the best possible dispersion with small size bubbles be achieved and that good mixing and the longest possible hold-up be obtained before the gas bubble coalesces, rises to the surface, and is lost.

METHODS OF RE-AERATION

The methods by which oxygen may be introduced into water and other liquids are legion. Many such methods are highly developed for specialized purposes. In this category, we can cite the aeration systems developed for fermentation processes and for bioxidation in sewage disposal plants. There are, in addition, many possibilities for adapting existing stream installations designed originally for purposes other than aeration at dams, weirs, water control gates, and the like. We mention these as possibilities, but it is apparent that the state of our knowledge and practice concerning actual use of these various alternate methods of accomplishing aeration are in an early stage of study and have not, in most cases, been tried on a sufficiently large scale to predict the cost and eventual values which might be obtained. The engineer faced with design problems for a re-aeration facility should recognize that these potentials may greatly decrease installation and operating costs whether by direct use to achieve the total desired degree of oxygenation of a river or indirectly through use of two or more measures, which together will meet the requirements at a particular location.

It is not unusual to find substantial degrees of reaeration are being accomplished unintentionally over sluices and through gateways designed and used for purposes other than reaeration. The use of baffles or other devices to increase turbulence may substantially increase the amount of aeration being accomplished where such situations exist. It is also often observed that natural sources of re-aeration have been substantially reduced in the course of constructing dams, navigation channels, water storage facilities, and the like, and there may be ways in which a proportion of this loss can be recovered through redesign or modification of the installation.

Gameson (*9*) studied the aeration of rivers over weirs in England and found that quite large amounts of oxygen may be absorbed in this way. Wagner (*10*) has reviewed a number of possibilities for introducing air in substantial quantities over weirs and sluices which have been tried or proposed for streams in Germany. The authors have observed a very substantial reaeration of the entire low water flows passing through gates into a power canal on a river in Minnesota where the dissolved oxygen concentration was increased

from zero level to a level of 4 p.p.m. Wagner has shown that installations of stream breakers, baffles, or other devices to increase turbulence may be a comparatively simple and inexpensive method for increasing the degree of re-aeration where substantial volumes of the total river flow pass through installations which take advantage of the existence of falling water. It is often found that dams are so constructed to give the smoothest possible flow and with the least degree of turbulence for waters passing over spillways and on to the toe of the dam. It seems quite likely that some of these facilities will be redesigned to give a greater degree of turbulence and to achieve re-aeration at relatively low cost. The excellent paper by Wagner (*10*) provides a compilation of quite a number of other possible ways in which aeration has been accomplished at existing installations on German rivers. His study includes compilation of calculated energy requirements or energy losses resulting from employment of these auxiliary methods of aeration. We must admit that many appear relatively inefficient when compared with installations which might be designed and constructed specifically for aeration purposes, but at the same time we must recognize that such installations do exist on many rivers and that they can accomplish substantial degrees of aeration which we can use to advantage.

Two cascade aeration weirs were specifically designed and installed recently to provide aeration on Badfish Creek several miles southwest of the City of Madison, Wis., at a point below discharge of the effluent from the Metropolitan Sewage District of that city (*11*). These installations having 4- and 8-ft. falls, respectively, are providing an excellent mixing of air with the water and give a surprising pickup in dissolved oxygen, amounting to a 3 p.p.m. increase of dissolved oxygen with summertime water temperatures.

Unfortunately, the areas which require aeration on rivers and streams are all too rarely located at points where it is possible to achieve sufficient degrees of aeration by use of new installations of this type or by easy modification of existing installations. It then becomes necessary to consider installation of mechanical methods for achieving the desired degree of re-aeration.

COMPRESSED AIR DIFFUSION

Tyler (*12*) proposed in 1942 that it might be possible to introduce compressed air into a river to alleviate critical conditions of low dissolved oxygen arising from wartime shifts in population. This idea was subsequently tried out on a river receiving spent sulfite liquor from 65 daily tons of pulp production with a large experimental installation carried out cooperatively near Park Falls, Wis., by the Flambeau Paper Co., the Sulfite Pulp Manufacturers' Research League, the Wisconsin State Board of Health, and with advice from Professor Tyler in 1943. Carborundum diffuser plates were mounted in flat aeration boxes and placed on the floor of the turbine outlets below the Pixley Dam in the first year of experimental trials. Air was supplied by a 100-hp. compressor delivering 1500 cu. ft. of air per minute at 16 p.s.i.g. Results of the first year of operation showed that substantial amounts of the oxygen introduced were actually absorbed by the water passing over the diffuser plates. However, it was recognized that efficiency was relatively low because the amounts of air provided were greater than could be introduced and diffused effectively through the limited amount of diffuser plate area exposed to the water. Further improvements were made in 1944. During the third year of operation at Pixley Dam still further design changes were made, and the National Council for Stream Improvement joined in sponsoring these studies in 1945. The final form of this installation included additional banks of tube-type Carborundum diffusers placed just ahead of the trash racks upstream from the water inlets to the power turbines. The possibility that the added air ahead of the turbines would affect their operation unfavorably or be cause for corrosion was considered and was subject for observation, but no such troubles were experienced. The added diffuser capacity did improve oxygen absorption efficiency considerably. This compressed air diffusion assembly was subsequently operated routinely during the critical season each summer for a total of 14 years until replaced by turbine aeration in 1957. The single operator for the hydroelectric plant also serviced the compressor and aeration assembly on a one-shift-per-day basis, with no serious operating problems or extra help required other than for occasional replacement of broken diffuser plates and the seasonal start-ups and shutdowns.

Oxygen absorbed by the diffusion of compressed air at Pixley Dam was calculated during a number of special stream studies conducted at the dam and found to average about 2875 lb. per day, with a high value of 3335 lb. under particularly favorable conditions. The absorption efficiency for the oxygen delivered to the water ranged around 6 to 8% and approached 10% at times.

The effect of the added oxygen deriving from diffusion of the air at Pixley Dam was much less than the original goal of maintaining at least 3 p.p.m. in water having 1 p.p.m. of dissolved oxygen or less prior to treatment. An appreciable increase was consistently observed following aeration, but it was usually on the order of 0.5 p.p.m. and only approached 1 p.p.m. increase under particularly favorable conditions. Nevertheless, the favorable effects of this aeration were substantial at points further downstream. The B.O.D. of the water was reduced more rapidly than without aeration, and dissolved oxygen levels rose to 3.0 p.p.m. and better at locations where critical conditions had formerly prevailed far downstream. Sport fishing and clean water biota of the stream moved upstream into formerly barren areas, with the substantial shortening of the stretch critically depleted in dissolved oxygen.

The overall conclusions derived from this long-term experiment with air diffusion to the entire low water flow of the Flambeau River show the results were promising, and on the whole they were considered practical, though not sufficiently outstanding to merit duplication at other locations at that time. Cost data are provided on a comparative basis in the discussion to follow on turbine aeration studies. It was and continues to be realized that much improvement in areation efficiency and in practical results are potentially available for this method, and it is quite possible that in the future situations will develop where forced air

diffusion may be applied to greater advantage than in the original installation at Pixley Dam.

TURBINE RE-AERATION

Late in 1955, Wagner (*13*) published results of pilot-scale experimental work on adaption of hydroelectric power turbines to river re-aeration conducted cooperatively with the Voith Co., a German supplier of power plant equipment. This paper reached our attention several months after an American power plant consultant, Bernhard C. Lueders, working independently on the idea, had contacted the Wisconsin State Committee on Water Pollution with suggestions for trial of turbine re-aeration.

Operating engineers at several hydroelectric installations were at best highly skeptical when first consulted about trying turbine re-aeration. Cavitation, corrosion of turbine wheels and draft tubes, and also excessive and damaging vibration, in addition to substantial losses of power, were all considered as serious problems which might result from introduction of large amounts of air. However, we had by that time had years of trouble-free experience with introducing air ahead of the turbines at Pixley Dam, and also quite a number of turbines installed at Wisconsin dams were equipped with vacuum release vents which were designed to admit rather large amounts of air to the draft chests when needed. It was decided to try and measure the effectiveness of introducing air to the water at several of these turbines equipped with vents, since no expense other than for power losses and stream analysis could be incurred, and it was only necessary to open existing valves to set up the experiment. Analysis of waters with and without aeration in this way showed that in some cases a substantial degree of oxygen pickup occurred, while at others the aeration effect was negligible. It was apparent that the design of the turbine and the manner of introducing the air to the turbine substantially effected the degree of aeration obtained. These preliminary experiments were conducted in 1956 and were considered sufficiently interesting to justify further work.

Cooperative trials were again set up by the Flambeau Paper Co., the Sulphite Pulp Manufacturer's Research League, and the Wisconsin State Committee on Water Pollution in 1957 and similar to that conducted from 1943 on the compressed air diffusion experiments at Pixley Dam. Mr. Lueders designed a modified turbine venting system to convert two double runner, horizontal turbines at Pixley Dam, and later the third unit was also equipped with a special double vent system. All air was introduced to the annular space between the runner ring and the conical shaped part of the turbine draft chest. At this point, it was determined that a vacuum ranging from 10.7 to 11.55 in. Hg existed. This was sufficient to draw in more than the desired amount of air as determined in later experiments, and it was found necessary to install check valves to control air admission.

The results of this first year of full-scale experimental work with turbine aeration on the Flambeau River showed that the dissolved oxygen content of the water could be increased as much as 1.57 p.p.m., with gross gains ranging from 525 to 9471 lb. of oxygen per day per 1000 c.f.s. of stream flow, depending upon conditions of temperature and the dissolved oxygen content of the water being aerated. The power loss as observed from direct reading of the meter panels in the power plant was calculated to be 1 kw. per hr. for each 4.87 lb. of oxygen absorbed by the water. No corrections were made in the first year of study for that power loss in terms of water held back and saved for later use as a result of the reduced volume passing through the turbines when air was admitted to the draft tube.

The results of this first year of study clearly showed that stream aeration by means of turbine venting was superior to aeration by the compressor and air diffusion system previously used at Pixley Dam. The amount of air absorbed by the water was approximately three times the amount which could be absorbed by air diffusion. The dissolved oxygen level was increased approximately three times over the maximum obtained by air diffusion. The cost of introducing oxygen appeared to be much less and also the cost of installation and of maintenance was considered to be a great deal less in comparison to that for air diffusion. The results of this first year of study were published in greater detail by Scott, *et al.* (*4*).

These studies were continued on a much expanded scale on Wisconsin rivers during the summer season of 1958, with turbine aeration at six power dams located on three different rivers under study. It was found that the amount of oxygen absorbed by the water in these several operations ranged from 1600 to 8200 lb. per 1000 c.f.s. of water flow each day that reaeration was practiced. The increase in dissolved oxygen content obtained at the several different power dams ranged from 0.35 to 1.51 p.p.m., with oxygen absorption efficiencies ranging from 15.2% to better than 25.7% for the large-scale turbine tests and as high as 56% absorption of oxygen on a smaller scale test operated for a few days under special conditions where a turbine operating at tail water level had insufficient suction to draw air by vacuum and a compressor was used to supply the air. An evaluation of the 1958 turbine reaeration studies indicated that 1.8 to 5.6 lb. of oxygen were being absorbed by the water for each kilowatt per hour of power loss, and that an extension of the daily calculations showed that the costs ranged from $3.00 to $15 per ton of oxygen absorbed in terms of loss of firm power valued at 1¢ per kw. per hr. More complete data describing the 1958 studies were given in a paper by Wiley, *et al.*, soon to be published (*5*). One of the most complete installations for turbine reaeration is located at the Rothschild Dam of Marathon, a Division of American Can Co., on the Wisconsin River where all six turbines have been fitted for reaeration and have been operated succesfully each year since 1957 (*14*). Sufficient air can be introduced at this power dam so that it was possible to maintain 3 p.p.m. of oxygen in the water aerated at this location during the critical season in 1958.

Still another season of river reaeration has been completed on Wisconsin rivers during the summer of 1959. Additional aeration facilities were installed especially on the Wisconsin and Lower Fox Rivers, and plans are being made for still more installations to be ready for operation in the summer season of 1960. Plans are also being made to aerate on the Wisconsin

River at as many as ten power dams during the winter of 1959 at any time when ice covers or other conditions causing critical levels of dissolved oxygen may require these auxiliary sources of oxygen. It is hoped that wintertime fish kills may in this way be eliminated on the Wisconsin River over the entire 150-mile stretch effected by industrial growth on that river.

COMPARISON OF COSTS

A number of engineering authorities have been consulted but it has still been found difficult to establish firm and reliable methods for calculating the cost of aerating a river, and especially so for turbine reaeration. In the latter case it can, of course, be a simple matter to read the loss in power output with and without air being admitted to the turbine. There is no question that with air admitted to the draft tube less water passes through and less power is produced at any given water gate opening. However, power plant authorities are agreed that such power panel meter readings do not give a true measure of power losses for a number of reasons. Probably most important is the fact that any water which does not pass through a turbine, and especially so when low water conditions prevail, is saved and available for use either through that turbine at a later time or through use of another turbine, which would not otherwise be operating at low water levels. On this basis, it has been calculated that the actual power loss may be about one third of that recorded on the meter for dams with moderate heads of 20 to 30 ft. and may even be insignificant on high head installations. Still another correction seems probable in that power losses observed with admission of air at any particular gate opening for water admittance to the turbine does not necessarily mean that it is not possible to open the gates and introduce more water and still with desirable amounts of air being added to the turbine. Preliminary experiments have indicated that it may not be necessary to reduce the power output as greatly as previously observed, and that the amount of air to be added to the turbine quite definitely should be controlled to give an optimum relationship between the amount of air being added, the amount of air being absorbed efficiently, the water throughput, and the amount of power produced. Wagner (*6*) has published a compilation of power loss data for his 1957 studies in Germany which are probably the most complete yet available. Power plant engineers and university authorities have joined in a preliminary study of these problems at Port Edwards on the Wisconsin River during August, 1959, and, although results are not available at the time of writing this paper, it is anticipated that more exact knowledge of the costs of turbine reaeration will be resulting from this study and from subsequent engineering evaluations in prospect.

We have prepared a preliminary comparison of costs, together with performance data, between turbine reaeration and the prior experience with air diffusion at Pixley Dam. This comparison is shown in Table I. Definite advantages for turbine aeration are apparent in lower capital charges for the original modifications or installation of re-aeration equipment, in the operating charges and costs of introducing the oxygen actually absorbed, in the amount of oxygen capable of being introduced, and in the efficiency of oxygen absorption.

Consideration of the data recorded in the upper

Table I. Comparison of Costs for River Re-aeration
(Based on best available average data from full-scale operations)

	Compressed Air diffusion	*Turbine re-aeration*	
	Pixley Dam (1945)	*Pixley Dam (1958)*	*Poppenweiler (1957)*
Number of tests	4	4	3
Stream flow, c.f.s.	880	317	752
Oxygen absorbed per day, lb.	2,875	3,330	11,650
Power used (or lost), kw. hr./day	1,320	1,040	2,960
Oxygen absorbed (lb. O_2/kw. hr.)	2.8	3.31	3.94
Oxygen absorption efficiency, %	6.8	25.6	44.9
Cost of power per ton O_2 absorbed	$12.85	$8.45	$7.10
Oxygen absorption potential, lb. O_2/1000 c.f.s./day	3,270	10,340	15,500
Seasonal cost to absorb 5 tons, O_2/day/1000 c.f.s. (45 operating days)	$2,900	$1,900	$1,600
Other maintenance costs per season	$1,000	Negligible	Negligible
Estimated installation costs (to give 5 tons O_2 absorption per 1000 c.f.s.)	$39,000	$2,000	(?)
Reference	(*16,17*)	(*15, 17*)	(*6*)

section of the Table should allow for difficulties in making close comparisons of information gained from tests made at different levels of water flow and with differing efficiencies in oxygen absorption. The authors have calculated the summary data in the lower lines to a common basis of 1000 c.f.s. of stream flow per day. With these allowances it is apparent that to achieve an absorption of 5 tons of oxygen for each 1000 c.f.s. of daily stream flow, a capital charge on the order of $2000 would be required to convert three turbines in an average hydroelectric power plant for turbine reaeration and that about three compressed air diffusion installations equivalent to that originally employed at Pixley Dam would be required at an estimated 1959 cost of $39,000.

Experience has in all cases shown the operating charges for turbine aeration other than for power costs to be negligible, but compressed air diffusion was found to cost $1000 per year or more for replacement of broken diffusers, cleanups, and for compressor maintenance.

Power costs per ton of oxygen absorbed were found to range from $12.85 for compressed air diffusion to $8.45 for turbine aeration at Pixley Dam in the 1948 tests, and $7.10 for the 1947 tests in Germany. Further experience in Wisconsin (*5*) has shown the potential power costs for turbine re-aeration to range from $3 to $15 per ton of oxygen absorbed. Further calculation of power costs are developed in the table to show the probable range of seasonal costs (45 days per year) to range from $1600 for turbine reaeration to $2900 for air diffusion in order to maintain an absorption of 5 tons of oxygen daily in a stream flow of 1000 c.f.s.

Other methods of introducing oxygen into rivers may eventually be developed which will prove to be as effective and economical as turbine reaeration, or alternately special conditions may permit its use even at lesser efficiencies or at greater cost. A number of such methods as aeration over weirs have been mentioned previously in this paper. We can also cite the

possibility of using pure oxygen where it can be made available in tonnage quantities at reasonable cost. The steel industry is known to use tonnage oxygen and there may be other locations where excess capacity for production of this gas could be available at a cost on the order of $20 per ton during critical periods of stream deoxygenation. It is known that one unit of the pulp and paper industry has conducted actual trials with pure oxygen, and more information on this installation may be available later.

FUTURE ADAPTION OF STREAM RE-AERATION PRACTICE

It will be interesting to observe the further development of use for re-aeration of a river by the turbine method and any other methods which may be found useful and effective. It is certain that our growing industrialization and growing population will continue to increase the number of rivers and locations where critical conditions of low dissolved oxygen will develop and prevail unless auxiliary methods of re-aeration are installed.

The importance being assigned to the role of turbine re-aeration in forthcoming stream pollution control practice can be appraised in the recent suggestion (*18*) of the Wisconsin State Committee on Water Pollution that turbine re-aeration facilities be installed and operated at 13 power dams on the Wisconsin River and five dams on the Lower Fox River. Additional installations on other rivers are likely to be requested to bring the total number to more than 20 units for the State of Wisconsin. To date, all such requests have been addressed to concerns operating in the pulp and paper industry, and with the understanding that use of river re-aeration facilities should not be considered as waste treatment but rather as an immediate step toward providing stream improvement until the B.O.D. loading on the rivers can be reduced.

The Advisory Committee on Waste Disposal of the Wisconsin Pulp and Paper Industry, at its April, 1959, meeting, went on record as supporting such a program for turbine re-aeration on the Fox and Wisconsin Rivers.

It can be concluded that the 15-year study of stream re-aeration reported in this paper has reached the stage of being a practical and economically accepted practice, which can be expected to be used extensively to alleviate or prevent the development of critical conditions of low dissolved oxygen on those rivers where conditions permit installation of suitable facilities. Turbine re-aeration appears as the first of a number of possible ways for achieving re-aeration to reach the stage of being feasible, but other methods for re-aeration of a river are potentially available.

CONCLUSIONS AND PROBLEMS

A 16-year program of evaluating the possibilities for reaeration of rivers in the State of Wisconsin has reached a practical stage of development. Several methods of introducing oxygen have been tested and turbine reaeration has been found particularly useful in alleviating critical conditions on large rivers where power dams are so located and other conditions permit use of this method. First experimental trials at three dams on three rivers in 1957 were followed by six operations at separate dams on these rivers in 1958, at eight hydroelectric plants in 1959, and the Wisconsin Committee on Water Pollution has recommended that operation be expanded to 19 separate dams on these three rivers for periods of critical deoxygenated water conditions in summer and winter seasons. Other methods of accomplishing reaeration in rivers and streams have been studied and should receive further evaluation and development.

Although this backlog of practical experience can be considered as grounded on well-accepted theoretical formulations, such as the oxygen sag curve of Streeter and Phelps and on the aeration formulation of Adeny, much remains yet to be learned from well-designed sanitary and hydraulic engineering studies. It is hoped that additional research on aeration methods and efficiency studies to fill this gap will be undertaken by universities and other research centers properly equipped and staffed for such work.

At the same time, we find increasing need for compilation of existing engineering data suitable for use in evaluating reaeration requirements and design of future installations. It is recommended that engineering and technical organizations concerned with stream pollution problems undertake compilation and dissemination of design data and standards for general use.

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A Method for Grinding and Calibration of the Valley Beater

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The investigation reported in this paper was undertaken for the purpose of finding a fast and effective procedure of grinding and conditioning the Valley beaters. The procedure finally chosen consisted of grinding with 80 grit emery and conditioning with 400 grit emery, both in pulp medium. The charges used are such that the gap between bedplate and roll during grinding are equal to the gap at commencement of beating normal test pulp. It was found that for good strength development and minimum fiber cutting the bedplate lead should be kept between 1/32 and 1/16 in., and the wooden fillers 1/32 in., below the level of the bars. A solid bar bedplate was found to give mild beating action which requires about twice the normal time to develop strength to maximum. Such beating might eventually develop greater than normal strength but longer beating times were not desirable for routine testing. The bedplate must be ground to a radius of curvature equal to the roll radius plus the gap sustained by the pulp normally tested in the beater. A beater ground for a pulp of one gap sustaining quality will not effectively develop the strength of a pulp of radically different gap qualities. It will (a) develop strength slowly if used for a pulp of lower gap qualities, (b) develop strength effectively if used for a pulp of equal gap qualities, and (c) cut fibers severely if used for a pulp of much greater gap qualities than the pulp for which it was ground. Because beating reduces the gap sustaining qualities of fiber, beater efficiency drops off as beating advances. Bedplate impressions must be taken with paper of total thickness equal to the grinding gap, hence equal to the test pulp gap at commencement of beating. The paper includes a complete routing procedure of inspecting, grinding, and conditioning of the beaters.

VALLEY beaters have been used at the Powell River Co. laboratory for the past 20 years. We now have three of them in use, one for routine testing, one for research work in conjunction with miniature digesters, and one which is reserved as a reference standard. As we produce only unbleached sulfite the routine and standard beaters are used only for this type of pulp but the research beater may be used for many different kinds of pulp.

Although we were using definite procedures of grinding and conditioning there were many times when the application of these procedures failed to bring the beaters back into calibration. Time was often lost in repeating some or all of the various steps of the procedures because of lack of clear knowledge of the exact results of these different steps. It was therefore decided that we should study the results of the steps of our procedures and the procedures used by other people for the purpose of finding a faster and more reliable method of grinding and conditioning.

Briefly stated, the following procedures were used:

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1. Grind by beating a charge of unbleached sulfite pulp containing 200 g. of 80 grit emery powder. The pulp charge had previously to be beaten to 200 C.S. freeness, standard weight was used on the beater arm, and the grinding usually took between 3 and 5 min.
2. Dull by beating a charge of unbleached sulfite pulp containing 200 g. of −40, +80 mesh sand. The pulp charge had previously to be beaten to 200 C.S. freeness, standard weight was used on the beater arm, and the dulling took between 20 to 30 min.
3. Check the beater condition by beating a fresh charge of sulfite pulp. If the freeness of this pulp after 35 min. of beating was about 425 C.S. freeness, conditioning was continued.
4. Condition by beating a series of 20 charges of sulfite pulp for 2 hr. each to a total of 40 hr. conditioning.
5. Check the condition of the beater by beating a charge of reference standard pulp. If the freeness and strength tests of this pulp were within specified limits of standard values the beater was accepted, if not, part or all of the grinding and conditioning procedures were repeated.

The reference standard pulp mentioned here is taken from production in 500-lb. bales. It is chosen for stability against aging effects and is usually cooked 8 hr. or longer. The normal procedure is to choose a new bale well before the old one has been used up and do aging test beater runs on it over a period of a year to determine its stable condition. When accepted as a reference standard, the pulp is used only for checking the condition of the beaters.

After grinding, a beater is not accepted as being in calibration unless it will reproduce the test values of the reference standard pulp within the following tolerance limits:

1. Time to 500 C.S. freeness: within ±3.5% of standard.
2. Mullen strength at 500 C.S. freeness and at maximum: within ±3% of standard.
3. Tear strength at 500 C.S. freeness: within ±5% of standard.

INVESTIGATION

Various methods of grinding, conditioning, and adjusting the bedplate and roll were studied in the investigation:

Grinding

1. Direct contact grinding with 80-grit emery powder.
2. Direct contact grinding with 400-grit emery powder.
3. Grinding with 400-grit emery in pulp.

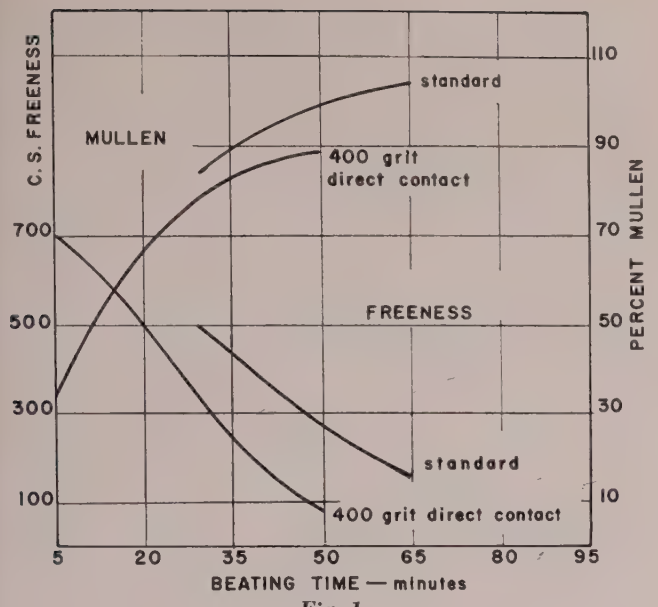

Fig. 1

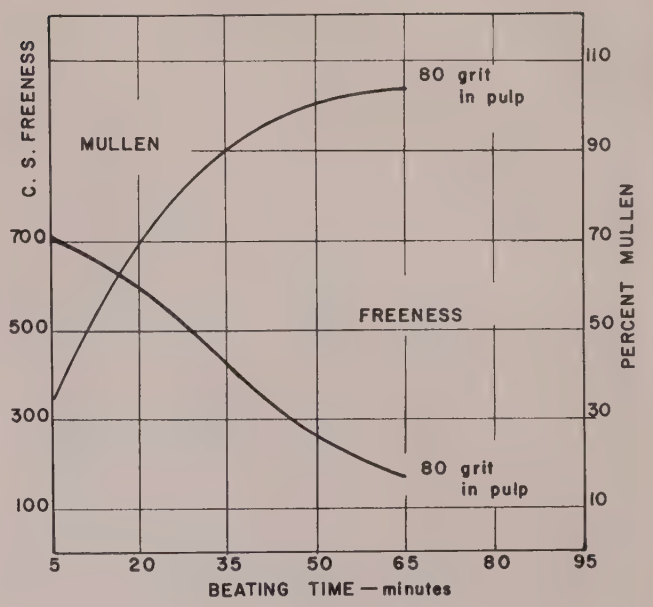

Fig. 2

4. Grinding with 80-grit emery in pulp.

Conditioning

5. Conditioning by beating fresh charges of pulp for 1 hr. each to a total of 40 hr.
6. Conditioning by beating fresh charges of low consistency pulp for 1 hr. each to a total of 7 hr.
7. Conditioning by beating 360-g. charges of −8 mesh spruce sawdust in water for 1 hr. each to a total of 9 hr.
8. Conditioning with a 2-min. beating of a pulp charge containing 50 g. of 400-grit emery powder.

Bedplate

9. Varying the level of the lead in front of the bedplate.
10. Replacing the wooden fillers of the bedplate with brass strips to give a solid bar bedplate.
11. Varying the height of the wooden fillers of the bedplate.
12. Raising and lowering the beater roll by the use of brass shims placed under the roll bearing housing base.

EXPERIMENTS AND RESULTS

Grinding

1. A grinding compound of 80-grit emery powder in water-soluble surgical jelly was applied directly to the roll bars and the roll was hand-turned to 80 rotations with the bedplate arm held at light contact pressure in its clamps. After grinding, the wire edges were removed from the roll bars, their lead edges rounded, and the beater conditioned with 34 one-hour pulp runs.

This grinding grooved the roll and bedplate bars deeply. The test beating of reference standard pulp showed that the beater reduced freeness very rapidly and developed burst strength quickly to a low maximum, both of which indicated severe fiber cutting.

Carbon and bond paper bedplate impressions taken after this grinding (method described below) showed that the amount of grinding had not been sufficient to completely alter the curvature of the bedplate to conform to the roll. The reference standard pulp test showed the condition to be far from standard and the method was not continued.

2. A grinding compound of 400-grit emery powder in water-soluble surgical jelly was applied directly to the roll bars and the roll was motor-turned at 10 r.p.m. for several hours until carbon paper impressions showed that the bedplate was completely ground in. Very light contact pressure was maintained by adjusting the arm clamps during the grinding. After completion of grinding the roll bars were cleaned up and the beater conditioned as in grinding with 80-grit emery.

Although the roll and bedplate bars were ground to a smooth finish the beater still reduced freeness very rapidly and developed burst strength quickly to a low maximum. Apparently fiber cutting was about as severe as in the case of 80-grit, direct contact grinding.

Figure 1 shows freeness and burst (Mullen) plotted against beating time of the reference standard pulp tested after 400 grit, direct contact grinding. Part of the standard burst and freeness curves are shown for comparison. It is reasonable to expect that if the previous 80-grit, direct contact grinding had been continued until the bedplate was completely ground in, the resultant beating values would have been at least as far from standard as in the case of 400-grit grinding.

3. A grinding compound consisting of 130 g. of 400-grit emery powder in a standard charge of unbleached sulfite pulp previously beaten to about 200 C.S. freeness was run in the beater for 15 min. at standard beating pressure. After grinding the beater was conditioned by the methods described in (1) above.

Test beating of the reference standard pulp showed acceptable beating time to 500 C.S. freeness and acceptable burst strength development, but after a few runs the beating rate slowed down beyond acceptable limits.

4. A grinding compound consisting of 200 g. of 80-grit emery powder in a standard charge of pulp previously beaten to about 150 C.S. freeness was run in the beater for 30 min. During this grinding the beater arm clamps, which are now supplied with the beaters, were used to maintain light contact pressure between the roll and the bedplate.

A carbon and bond paper bedplate impression taken at a paper thickness of 0.008 in. showed a uniform fit of the bedplate. When actual measurements (described below) showed that the space or gap between the roll and bedplate at commencement of beating unbleached sulfite pulp was only about 0.004 in., the amount of emery powder was reduced to only 80 g. in order to reduce the grinding gap to this amount.

This grinding with 80-grit emery, in pulp of a bulk which gave a bedplate roll-gap equal to the gap sustained by the pulp at commencement of beating, developed the strength of the reference pulp to the desired amount. The beater condition was not sufficiently stable, however, until the pattern of the grooving cut by the emery was more deeply set into the roll and bedplate bars by an additional grinding of 30 sec. duration, using a similar pulp-emery charge but releasing the beater arm from its clamps and allowing the bedplate to contact the roll at standard beating pressure.

Figure 2 shows freeness and burst (Mullen) plotted against beating time of the reference standard pulp beaten after the 80-grit emery and pulp grinding. The freeness and burst values of this test were so close to standard that only one set of curves is shown.

It was decided that grinding with 80 g. of 80-grit emery in 150 C.S. freeness beaten, unbleached sulfite pulp, with the beater arm held in its clamps at light pressure, and followed by a 30-sec. grind with a similar pulp-emery charge at standard beating pressure would be adopted as our grinding procedure.

Conditioning

Grinding with 80-grit emery gives the desired deep grooving of the roll and bedplate bars but the sharpness of the peaks presumably results in an unstable condition and in fiber cutting. Therefore these sharp peaks must be dulled. Conditioning is intended to round-off the peaks and bring the beater to a stable condition as quickly as possible. The sand dulling method previously used had a tendency to sharpen rather than dull the beater. The following conditioning methods were tried in the search for a better procedure.

5. A series of 40 one-hour runs using standard charges of unbleached sulfite pulp were made at standard beating pressure. These runs successfully dulled the bar grooving and resulted in a stable beater condition without changing the curvature of the bedplate but the method was very time consuming.

6. A series of 7 one-hour runs using 23 l. of 1.17% consistency, unbleached sulfite pulp were made at standard beating pressure. It was thought that the low consistency pulp would allow closer contact between the beater roll and the bedplate and consequently condition the beater in a shorter time. Comparison of bedplate impressions taken before and after this conditioning showed that the low consistency pulp resulted in a reduced gap between roll and bedplate and, because of the arc through which the bedplate moves, allowed the back bars of the bedplate to come into closer contact with the roll than the front bars (Fig. 4a). As a result the back bars were so badly worn that re-grinding was necessary.

7. A series of 9 one-hour runs using 360 g. of −8 mesh sawdust in 16 l. of water and with standard beating pressure was tried. The sawdust broke down very rapidly, the gap it sustained was quickly reduced, and the end results were similar to those obtained with low consistency pulp conditioning (6). The back bars of the bedplate were worn down and when the reference standard pulp was beaten, fiber cutting was found to be severe, apparently because this wearing down of the back bars resulted in higher unit pressure on the front bars when pulp of normal gap qualities was beaten. Again re-grinding was necessary.

8. By this time a gap measuring instrument, described later, had been installed and it was decided to try using a conditioning charge of pulp and fine emery at a gap equal to that sustained by normal pulp at commencement of beating, in our case about 0.004 in.

It was found that 50 g. of 400-grit emery powder in a standard charge of unbleached sulfite pulp which had previously been beaten for 5 min. (to between 690 and 700 C.S. freeness) met these requirements. Two minutes of beating this conditioning charge were found sufficient to round-off the sharp peaks left by 80-grit emery grinding and to bring the beater to a stable condition without altering the curvature of the bedplate. This method of conditioning was adopted as routine procedure.

Adjustments to the Bedplate and Roll

9. It had been our practice to cut away some of the lead from in front of, and behind the bedplate. The purpose of this step was to keep the lead from contacting the roll bars and filling in the grooves cut by grinding, consequently changing the beating characteristics. However the fact that cutting of the fibers may occur if the front bar of the bedplate is high above the lead made it necessary to determine how far down the lead should be cut. The level of the lead was therefore varied from level with the bars to $^{3}/_{16}$ in. below the front bedplate bar. No changes were made in the level of the lead behind the back bar as it has no effect on beating as long as it is kept down where it cannot contact the roll bars.

When the lead was level with the top of the front bar of the bedplate the beating action was slowed down considerably.

When the front bar was exposed by more than $^{1}/_{16}$ in. fiber cutting resulted as indicated by rapid freeness reduction and development of burst strength to a lower maximum than standard.

It was found that fiber cutting could be controlled and beating time maintained by keeping the level of lead in front of the bedplate between $^{1}/_{32}$ in. and $^{1}/_{16}$ in. below the bar level.

10. Because the white oak fillers with which the bedplates are made wear down with beating, it was desired to know what part they play in beating and what changes result from this wear. The wooden fillers were therefore replaced with brass strips and the level of these fillers was varied from flush with the bedplate bars (essentially a solid block bedplate) to about $^{1}/_{32}$ in. below the level of the bars.

The solid bar bedplate, even when ground with 80-grit emery, gave a very slow beating action and low strength development although it is possible that prolonged beating would have eventually given good burst development. Such mild, long time strength

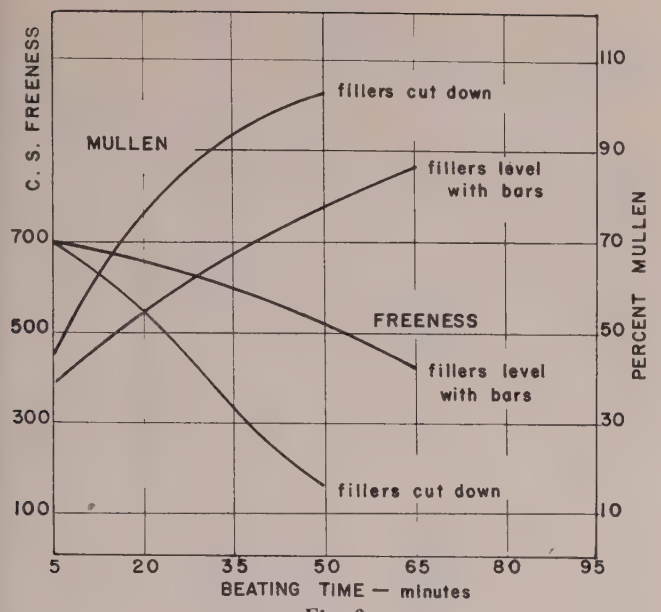

Fig. 3

development might more accurately tell the true strength potential of the pulp fibers but the time involved would not be acceptable for routine, daily test purposes.

When the brass was cut down $^1/_{16}$ in. in front of the leading edge of each bar, freeness reduction was much faster and Mullen strength development came up to about the standard maximum after 50 min. of beating.

Figure 3 compares freeness and burst (Mullen) plotted against beating time of the reference standard pulp beaten first with the solid bedplate and again after cutting the fillers down to return to a normal bar bedplate condition.

The difficulty of cutting brass fillers down without damaging the bars made them unsatisfactory and white oak fillers were reverted to.

11. It was now apparent that a difference in level between the bedplate bars and fillers was required to obtain the desired beating rate. The degree of difference required was the next point of interest. The height of the wooden fillers was therefore varied from bar level to about $^1/_{16}$ in. below bar level.

At bar level there is a strong possibility of the wood swelling during beating and contacting the roll bars with the result that beating action would be reduced even below the beating rate of the solid bar bedplate. On the other hand, when the fillers were cut down more than about $^1/_{32}$ in. below the bar level, fiber cutting increased with consequent rapid freeness reduction and low burst strength development.

The angle at which the filler tops meet the bars was also varied and it was found that if the tops of the fillers were sloped upward from about $^1/_{32}$ in. below the trailing edge of the bars to the level of the top of the following bars, the effect was the same as if a solid bar bedplate were used. If the fillers were sloped downward from the level of the top of the trailing edge of the bars to about $^1/_{32}$ in. below the lead edge of the following bars, beating rate and strength development were about the same as when the filler tops were cut flat and $^1/_{32}$ in. below the bars.

It would appear that the white oak fillers normally wear down at a rate sufficient to keep them just below the bar level and occasional scraping is all that is required.

12. Wear of the bedplate bars has the effect of allowing the bedplate to come closer to the roll. However, because the bedplate arm moves through an arc, the result of bringing the bedplate closer to the roll is to change the contact angle between the roll and bedplate. It was thought that if the beater roll could be lowered vertically an amount equal to the wear, then the original fit might be re-established because the bedplate would be returned to its original position on its arc. To try this theory the beater roll and bearing housing were removed before grinding, the surfaces of the bearing housing base were thoroughly cleaned and coated with a thin film of oil, two 0.002 in. brass shims were placed under each foot of the bearing housing, and the beater was re-assembled. When the beater had been used to the point where the bedplate impressions showed too faint contact of the front bars and the beating rate had slowed down, one brass shim was removed from under each bearing housing foot and another impression was taken. This impression showed that the original fit had been practically restored and it was possible to use the beater for some additional time without regrinding.

Use of these shims was therefore included in the grinding procedure. They have given sufficient adjustment on several occasions to postpone grinding for worthwhile times.

BEDPLATE IMPRESSION METHOD

Bedplate impressions are used as a means of determining the fit, degree of wear, and radius of curvature of the bedplate. The method of taking these impressions is as follows:

After letting the bedplate sit in water so that the wooden fillers have ample time to swell to the full amount, the beater is drained and all excess water is dried off the roll and bedplate with blotting paper. A piece of bond paper and a piece of carbon paper are then chosen so that together they caliper a thickness equal to the gap at which the impression is desired, in our case about 0.004 in. These pieces of paper are then cut slightly wider than the bedplate and about $8^1/_2$ in. long.

Together they are placed, carbon paper on top next to the roll and carbon side against the bond paper, between the bedplate and roll with the left hand while the right hand holds the weight arm up to disengage the bedplate. While the paper is held firmly against the bottom of the beater with the left hand the weight arm is gently lowered to bring the bedplate and the roll into contact with the paper, the roll is now turned carefully through about half a rotation with the right hand. Finally the bedplate is disengaged and the paper is removed.

If properly taken, this impression will show the fit of the entire bedplate, the texture of the grooving of the bars, and any swelling of the wood fillers above the level of the bars.

While the method is very simple it is an important means of determining the condition of the beater before any grinding is done or any adjustments made. A point of great importance is the thickness of the impression paper, this should be equal to the gap be-

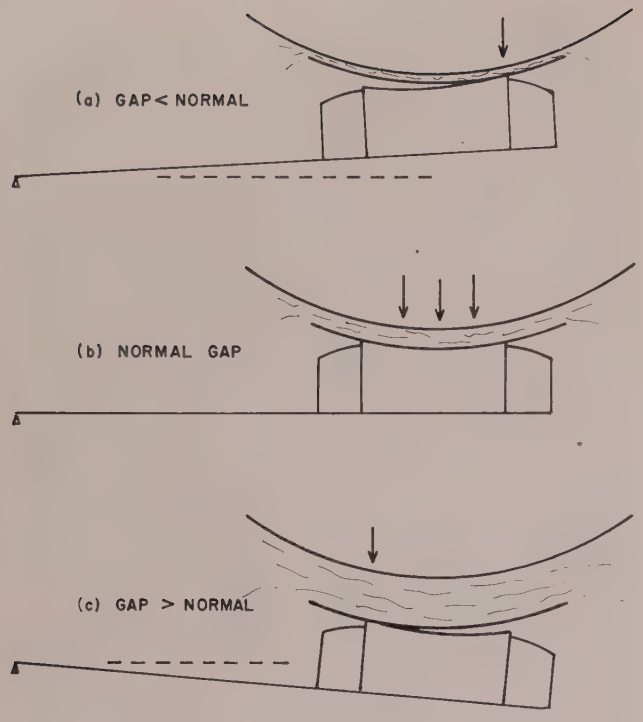

Fig. 4

tween the roll and bedplate during grinding, which in turn should be equal to the gap sustained by the pulp at commencement of beating.

GAP MEASURING METHOD

Glover, Ray, and Pritchard (*1*) described their method of measuring the gap between the beater roll and bedplate and showed that different pulps have quite different gap sustaining characteristics, both at commencement of beating and during beating.

With this thought in mind, bedplate impressions were made at approximately 0.004 in., 0.008 in., and 0.012 in. gaps when the beater had been ground to a gap of 0.008 in. This was done simply by varying the thickness of the paper used to take the gap impressions.

Comparisons of these three impressions showed that the 0.008 in. gap impression was uniform across all bars, the 0.004 in. gap impression showed strong contact of the back three bars but practically no contact of the front three bars, and the 0.012 in. gap impression showed very strong contact of the front bars but practically no contact of the back bars.

It seems clear that, in the same beater and due to the rotational movement of the beater arm around its fulcrum point, increasing the gap and decreasing it will shift the point of most prominent contact all the way from strong contact of the front bars, through even contact of all bars, to strong contact of the back bars, as is illustrated in Fig. 4.

It was gathered from this, and later shown by beater tests, that:

a. Beating a pulp of lower gap sustaining qualities than the original gap at which the bedplate was ground will result in a milder beating action with slower freeness reduction, slower strength development, and little fiber cutting, Fig. 4a.

b. Beating a pulp of gap sustaining qualities equal to the original grinding gap will produce the most effective results, giving good strength development for the desired beating rate and without too much fiber cutting, Fig. 4b.

c. Beating a pulp of greater gap sustaining qualities than the original gap at which the bedplate was ground will result in severe cutting of the fibers, hence rapid freeness reduction with poor strength development, Fig. 4c.

As a proper relationship between pulp bulk and radius of curvature of the bedplate was seen to be required for the best strength development, it was necessary to determine the gap sustaining qualities of our unbleached sulfite pulp. The necessary measurements were made by equipping one beater with a Mason-Neilan pneumatic motion transmitter fitted with a gage giving the gap distance in 0.0005 in. graduations. This instrument was calibrated against brass shim stock of known thickness placed between the roll and bedplate.

Measurements with this equipment showed that the gap of our unbleached sulfite pulp at commencement of beating averaged about 0.004 in., therefore the amount of 80-grit emery being used in the grinding compound was reduced to a point where the gap measurement of the compound was also about 0.004 in. After grinding with this reduced bulk compound the bedplate impression taken with paper of about 0.004 in. total thickness showed uniform contact over the whole bedplate.

It is considered evident that, because the bedplate moves in an arc, the angle of contact it makes with the roll plus the pulp carried with it varies for all changes in gap.

As beating advances, the gap sustaining qualities of the pulp are reduced, and the angle of contact between roll and bedplate changes, giving greater back bar contact (Fig. 4a), consequently the beating action becomes milder as beating time advances. In the case of our own unbleached sulfite it was found that gap dropped from 0.004 in. at commencement of beating to 0.0015 in. after 65 min. of beating. This is probably one of the reasons why freeness and strength curves level off as beating advances.

Furthermore, because different types of pulps have considerably different gap sustaining qualities (Glover, Ray, and Pritchard report the gap of hardwood sulfate at 0.0015 in. and of bleached sulfate at 0.0065 in. (*1*), a beater which has been ground to give the best strength development for one pulp may either severely cut the fibers of another pulp or fail to effectively develop its strength in a given time, depending on whether it sustains a greater or a lesser gap than the pulp for which the beater was ground. Many of the discrepancies between beaters may stem from the fact that their bedplates have been ground to different curvatures which would be expected to give quite different results if they were all used to beat the same pulp. It may be that it is neither possible nor desirable to universally standardize all beaters. Probably the best that can be done is to set each beater up to get minimum fiber cutting and maximum strength development from the pulp the beater will normally be used to test.

Based on the findings of this investigation the following procedures of inspection, grinding, and conditioning have been adopted as our standard procedure.

INSPECTION

To be carried out when there is any indication that the beater is out of calibration, such as change of time to 500 C.S. freeness.

1. Check the roll speed and inspect the drive belt. The roll should be driven at 500 ± 10 r.p.m. and there should be no slipping of the belt.

2. Check the weight on the beater arm in excess of that required to balance the bedplate when the beater contains 23 l. of water. Calculated as beating pressure this must equal 10,700 ± 100 g.

3. Take an impression of the bedplate. Inspect the impression for any uneveness across its width or from front to rear, any indications that the wood fillers have come up to the bar level, and any sign of shoulders on the sides of the bedplate.

4. Inspect the bedplate diaphragm, look for any cracks in, or signs of deterioration of the rubber.

5. Remove the beater roll and bearing assembly and inspect the bedplate. The lead should be $^1/_{32}$ in. to $^1/_{16}$ in. below the front and back bars and if grinding is necessary this distance should be a full $^1/_{16}$ in. before grinding is started. The wood fillers should be about $^1/_{32}$ in. below the level of the bars at all points. The bars should be deeply but not sharply grooved and there should be no shoulders on the sides of the bedplate.

6. Inspect the beater roll. The bars should be deeply but not sharply grooved. The lead edges should be distinctly rounded and the trailing edges should be free of wire edges. Inspect the ends of the bars for any signs of riding up on bedplate shoulders.

7. On the basis of the information gained from the inspection decide what work is necessary to bring the beater back to standard condition.

8. Thoroughly clean the assembly bases with a vacuum cleaner, remove any rust with fine emery cloth, and wipe a film of oil over all the base surfaces. Place two new 0.002 in. brass shims under each foot, protruding on one side for ease of removal. Re-assemble and tighten the base down to an even fit on all corners with a torque wrench.

GRINDING AND CONDITIONING

Alignment Grinding

1. Prepare a standard charge of sulfite pulp beaten to about 150 C.S. freeness.

2. With the bedplate disengaged circulate the pulp for 5 min. during which time slowly sprinkle 80 g. of 80-grit emery into the charge to ensure a well-mixed grinding compound.

3. Remove hanger and all weights from the beater arm.

4. Lower the arm until light contact between the bedplate and roll is obtained and lock it in this position with the arm clamps.

5. Run the beater for 30 min. adjusting the arm as often as necessary to maintain light contact.

6. Empty the beater, wash thoroughly with water, dry, and take an impression.

7. If the impression indicates that alignment is not as desired, repeat steps 5 and 6, using a fresh charge each time until an even impression is obtained, at which time proceed to the next step.

Grooving Grinding

1. Replace the hanger and weights on the beater arm.

2. Prepare a pulp-emery charge exactly as for grinding.

3. Engage the bedplate and run the beater for 30 sec. Empty the beater and wash thoroughly with water.

4. Remove the beater roll and bearing assembly.

5. Trim off the wire edges of each roll bar and round off not more than $^1/_{32}$ in. of the leading edge, using a fine, flat file in both cases. Do not bevel the lead edge.

6. Inspect the bedplate and remove shoulders that may have formed on the sides. Trim down the lead in front and behind the bedplate between $^1/_{32}$ to $^1/_{16}$ below the level of the bars. If necessary trim down the wood fillers evenly to about $^1/_{32}$ in. below the surface of the bars.

7. Clean out the beater, re-assemble, and take an impression. If the impression is not uniform repeat alignment and grooving grinding, otherwise proceed to the next step.

Conditioning

1. Prepare a standard charge of sulfite pulp beaten for 5 min.

2. With the bedplate disengaged circulate the pulp for 5 min. during which time slowly sprinkle 50 g. of 400-grit emery into the charge to ensure a well-mixed grinding compound.

3. Engage the bedplate with standard weights on the beater arm and grind for 2 min.

4. Empty the beater and clean it by circulating a standard charge of sulfite pulp for 20 min. with the bedplate disengaged, then wash it out thoroughly with water.

5. Take an impression and if it shows the front bars slightly faint, the beater may be accepted, if the front bars are particularly faint, remove one shim from each base footing and take a new impression. If the new impression is poor, grinding must be repeated.

6. If the impression is acceptable, beat a charge of reference standard pulp and compare the test results with the standard values.

7. If freeness reduction is too fast, take the following steps one at a time, checking the results before proceeding to the next, and proceed to the next only if necessary.

   a. Inspect the leading edges of the roll bars, be sure they are rounded, not bevelled.
   b. Repeat conditioning.
   c. Insert a 0.001- or 0.002-in. shim under each foot of the bearing assembly.

8. If freeness reduction is too slow and strength development too low, take the following steps one at a time, checking the results before proceeding to the next and proceed only if necessary.

   a. Remove a 0.002-in. shim from under each foot of the bearing assembly.
   b. Repeat the grooving grinding and conditioning steps.

The test methods used in this investigation were TAPPI Standards, as follows:

Beater method, T 200 m-45

Sheet making, T 205 m-58
Sheet testing, T 220 m-53
Freeness testing, T 227 m-50

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1. Glover, G. F., Ray, P. F., and Pritchard, E. J., "An Investigation of the Beating Process with the Aid of the Valley Laboratory Beater," Symposium on Beating, Sixty-first General Conference, The Technical Section of the British Paper and Board Makers' Association (Inc.), 32, pt. 2 (1951).

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Cationic Starches as Paper Coating Binders

DONALD S. GREIF

Cationic starches are examined as coating binders and a comparison is made with standard coating starch binders as well as coatings to which cationic surfactants have been added. The viscosity, water retention, rheology, and pick resistance of these coatings are examined from a laboratory viewpoint. It is shown that the cationic starches and surfactants can be used to control the viscosity increase in coating formulations and that coatings at reduced solids can be prepared, possessing the rheological properties of coatings prepared at higher solids from standard procedures. The particular advantage of the cationic starches to increase the pick resistance of a coating even at reduced solids is outlined and their use in lightweight coatings is suggested. The effect of reducing coating binder is examined illustrating the maintenance of coating specifications when utilizing the cationic starch as a total or partial replacement for a standard starch binder.

The requirements of reduced basis weight in coated publication papers and the necessary reduction in coating weight have certainly produced new advances in the technical aspects of coating. There is little doubt that the demand for lightweight coatings will promote the use of new coating machines capable of applying lightweight coatings uniformly, and require new formulations to obtain the desired machinability and print characteristics. Those mills utilizing the more conventional roll coaters must reformulate their colors to retain high quality. The suppliers of coating materials are quite aware of the improvements that can be of benefit in this field, i.e.:

Pigments—higher opacity and brightness, lower binder demand.

Binders—higher binding power, improved water retention and machinability, less effect on reducing ink receptivity and opacity.

While the interest in lighter weight coatings has highlighted the paper coater's need for the above improvements, many other desirable features are constantly in demand for all phases of pigment coating.

The application of synthetic resins to paper coating some years ago has certainly proved to be of benefit to paper mills in producing high quality coated papers. The binding strength, machinability, and effect on print quality of these materials are constantly being improved. In addition, many new and unique properties are being built into these products to provide even more improvement for the future. Nevertheless, resin binders are by no means the complete solution to the problems and desires of present and future paper coatings. Starch, the most widely used binder (*1*), will be relied upon to the largest extent to furnish binding, machinability, and proper lay of coatings at an economical cost. Starch chemistry is becoming as much of a science as synthetic polymer chemistry and the paper industry can look forward to many more chemical modifications of starch than are now available.

Development work on lowering coating weights applied on roll coaters has emphasized the need for stable, high water retaining and high pigment binding starches with improved flow characteristics. In this regard, preconverted starch products have led to quality improvements beyond those obtainable with enzyme converted pearl starches. More recently, chemical modifications of starch such as the starch acetates have been commanding wide interest. The benefits derived from these starches such as, added water retention, pigment binding, and filminess of the coating are primarily due to the changes in the physical properties of the starch imparted by the modifying chemical. While altering the physical properties of starch binders has certainly benefited paper coating, we have long felt that promotion of a chemical reaction between the starch and pigment and/or cellulose fiber may afford the greatest potential benefits.

Preliminary investigation of cationic starches has indicated a definite attraction between the starch and both anionically charged pigment and fiber. This work gives evidence that a definite chemical bond is formed between the cationic starch and cellulose (*2*). While highly cationic starches will tend to flocculate pigment, low percentage treatments have proved effective in altering the flow properties of coating and in turn anchoring these coatings chemically to cellulose.

This paper is in regard to the progress thus far obtained in investigating these electrochemical starches and is designed to bring an awareness of the opportunities available to the starch researcher in drastically modifying the natural product into a chemical entity. It is by no means a complete report on the subject and the cationic starch referred to in this work is experimental and is not necessarily representative of future commercial production.

The data to be presented will illustrate how the po-

Table I. Viscosity Effect of Typical Cationic Surfactants

Cationic surfactant	*Brookfield viscosity 20 r.p.m. 110°F., cp.*
1. Quaternary amine	35,750
2. Primary amine	106,000
3. Quaternary pyridinium compound	26,200
4. Secondary amine	74,000
5. Tertiary amine	72,000

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tential use of a cationic starch can influence the base viscosity, high shear viscosity, flow properties, and pick resistance of coatings prepared on a laboratory basis.

Comparison is made with a commercially utilized preconverted starch binder. The effect of a cationic surfactant addition to typical coating formulations utilizing the same preconverted starch binder, is also compared. Coatings were prepared over the solids range of 50 to 62% with viscosities varying between 1800 and 50,000 cp. as tested by a Brookfield viscometer at 20 r.p.m. and 100°F.

The cationic starch used in this work is a derivative containing substituent groupings possessing cationic properties. These may be imparted by several techniques, e.g., through introduction of nitrogen groups (*3*). In this particular phase of the work reported, the active grouping is a tertiary nitrogen which is capable of forming salts. In water, these salts hydrolyze giving a positively charged starch radical.

$$\text{Starch—R—}\underset{\underset{\text{H}}{|}}{\overset{\overset{\text{R}'}{|}}{\text{N}}}\text{—R}'' \xrightarrow{\text{H}_2\text{O}} \text{Starch—R—}\underset{\underset{\text{H}}{|}}{\overset{\overset{\text{R}'}{|}}{\text{N}}}\text{—R}''^{+} + \text{X}^{-}$$

Such groupings being positively charged have a natural affinity for negatively charged particles or surfaces.

PROCEDURE

The procedure used follows standard, coating color preparation methods. In all cases a nondispersed coating clay (82% under 2 μ particle size) was utilized. The clay slip was prepared at 70% anhydrous solids using sodium hexametaphosphate and caustic at levels of 0.25 and 0.1% on the weight of pigment, respectively. The starches were cooked at 195°F. in a jacketed kettle for 20 min. using mechanical agitation. The order of addition of materials was as follows:

A. Clay slip
   1. Water
   2. Sodium hexametaphosphate
   3. Caustic
   4. Clay
B. Starch cook
   1. Water
   2. Starch
   3. Heat

The starch cook was added to the clay slip under agitation. This was followed by the addition of the various additives as outlined. Base viscosity was measured at 20 r.p.m. at 110°F. on the Brookfield viscometer (RVF model). The standard Brookfield procedure was utilized. Water retention was then measured utilizing the base stock used in testing coating pick by the following procedure (*4*).

A sample of coating color is placed on a watch glass and a portion of the base stock suitably stained on the wire side is placed felt side down on the color. The time reported, in seconds, for the stain to react with the transmitted water is reported as water retention.

Following this, $^1/_2$-ml. wet coatings are applied to base stock and dried at 221°F. for 1 min. Wax picks are taken utilizing the TAPPI Standard procedure.

The Hercules high shear viscometer was used to plot the high shear viscosity changes in line with procedures

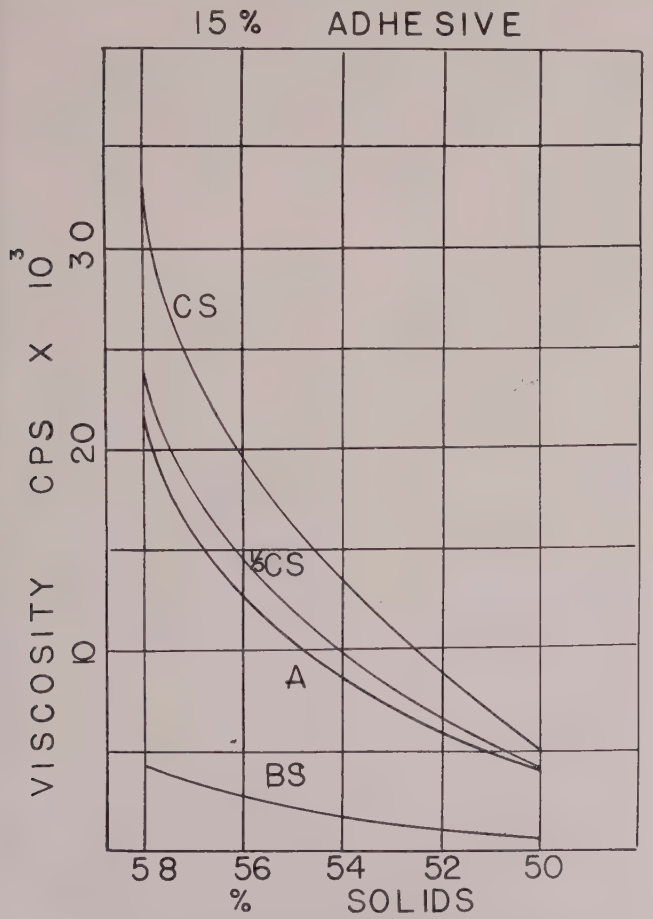

Fig. 1. Effect of solids on viscosity at constant adhesive ratio

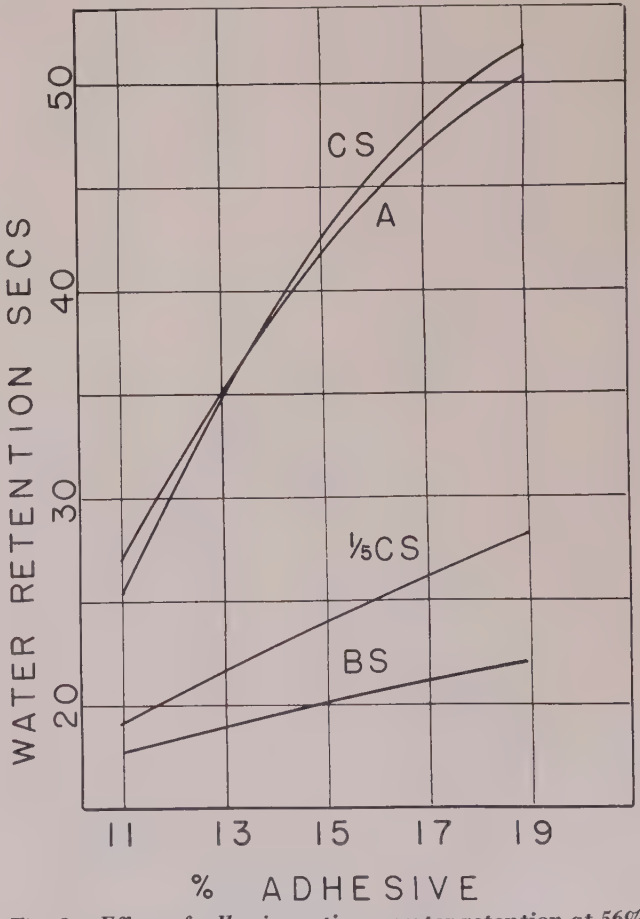

Fig. 2. Effect of adhesive ratio on water retention at 56% total coating solids

Table II. K_1 and K_2 Values for Coatings at 56% Total Solids Containing the Indicated Binder System at 11 to 19% Adhesive Ratio

Adhesive, %	*19*	*17*	*15*	*13*	*11*
U_1[a]$/WR$	67	70	69	69	73
log U_1/WR	0.065	0.074	0.079	0.086	0.098
U_2[b]$/WR$	496	296	184	191	164
log U_2/WR	0.061	0.060	0.062	0.091	0.098
U_3[c]$/WR$	494	446	383	239	86
log U_3/WR[d]	0.061	0.071	0.073	0.077	0.072

[a] U_1 = Viscosity of coating containing base starch in, cp.
[b] U_2 = Viscosity of coating containing base starch plus surfactant in, cp.
[c] U_3 = Viscosity of coating containing cationic starch in, cp.
[d] WR = Water retention.

outlined by the Martinson Machine Co. Temperature of the coating was maintained at 110°F.

PRELIMINARY DISCUSSION

While many cationic starches were examined we will report on one viscosity grade to simplify the paper. The cationic starch (referred to as CS in illustrations) is compared to:

1. A preconverted coating starch with a viscosity equivalent to the cationic starch and which will be referred to as the "base starch" (BS in the illustrations).

2. The base starch (BS) in case 1 modified with the addition of 0.5% of a cationic surfactant (referred to as "A") on the weight of clay. Several cationic surfactants were evaluated for their viscosity effect on coating colors and are reported in Table I.

3. The base starch modified by a 20% replacement with the cationic starch.

In Table I the coatings were formulated at 58% solids utilizing 18% of the base starch with 0.5% of a surfactant on the weight of clay. The surfactant chosen for comparison in the paper is no. 1 in the Table, a quaternary amine. The reason for choosing this particular material was its ease of formulation. No particular advantages were noted with any of the other materials aside from their ability in some cases to increase viscosity to a greater extent based on the same sample weights.

A major difference noted between a coating based upon a standard starch preparation and a cationic starch preparation is the viscosity effect. While the cooked starch viscosity of the standard starch and its cationic derivative are quite similar as prepared, upon addition to a clay slip the cationically modified coating

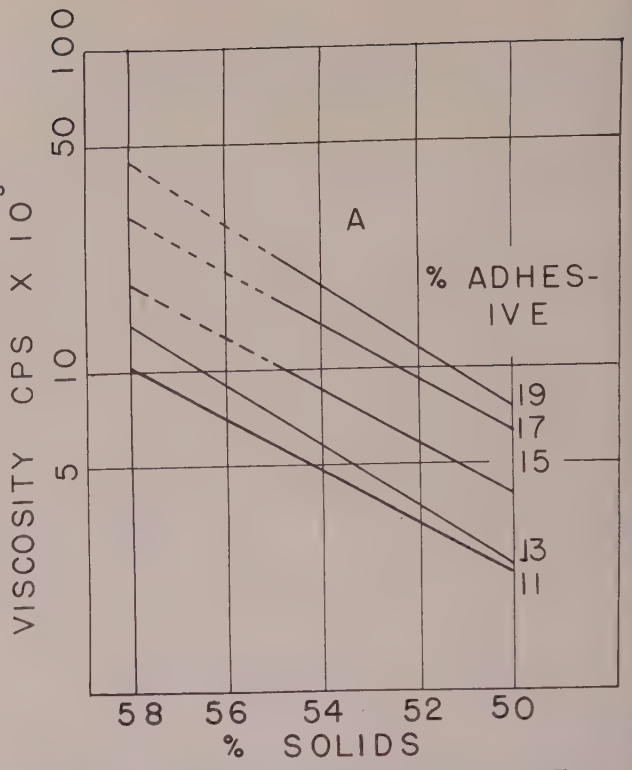

Fig. 4. Effect of solids on viscosity at varying adhesive ratios on the cationic surfactant modified coating

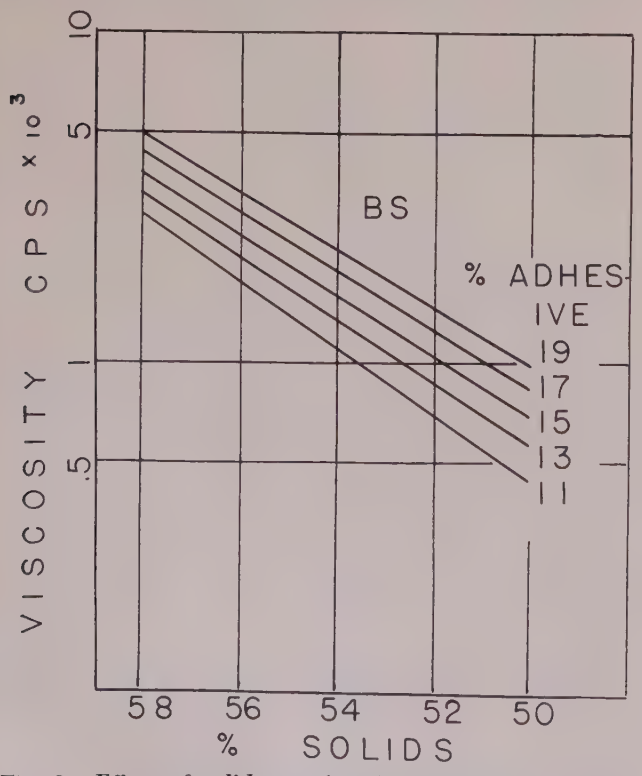

Fig. 3. Effect of solids on viscosity at varying adhesive ratios on the base starch coating

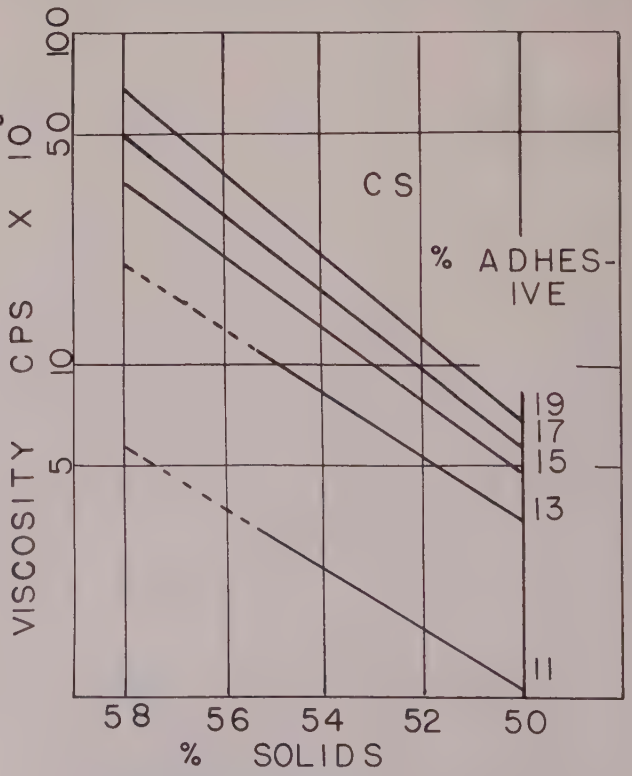

Fig. 5. Effect of solids on viscosity at varying adhesive ratios on the cationic starch coating

Table III. Data on the Five Coating Formulations Represented in Figs. 6–10

	Figures				
	6	7	8	9	10
Starch	BS[a]	BS	CS[b]	CS	BS
Additive	...	A[c]	...	...	...
Coating solids, %	62	53	56	53	57
Adhesive on clay, %	15	15	15	15	19
Viscosity, cp.	16,000	4400	23,000	10,000	4300
Area within the curve	31	23	35	23	19
Yield value	2.4	2.2	1.2	1.4	1.4
Wax pick	7	5+	8	8+	8

[a] BS = Base starch.
[b] CS = Cationic starch.
[c] A = Quaternary amine.

will exhibit a much higher viscosity. This leads us to believe that the cationic treatment has its main viscosity effect on the clay.

Illustrating this point further, when a cationic surfactant is added to the standard starch cook very little effect on viscosity is noted. However, the same surfactant when added to the clay slip will increase its viscosity similarly to the increase noted when adding the chemically treated cationic starch. This is dissimilar to viscosity increases noted in coatings modified with starch plasticizers, such as stearates, where the primary increase in viscosity takes place in the starch portion of the coating. The effects of plasticizers will be compared to the cationic modifications in future work.

Viscosity Data

Figure 1 illustrates the viscosity effect of the various binder systems. You will note that the three cationically modified systems show large increases in viscosity over the base coating starch. It can be readily seen that when utilizing the cationic modification a decrease in solids to 50% will yield a viscosity similar to the unmodified starch at 58% solids. This, however, can be

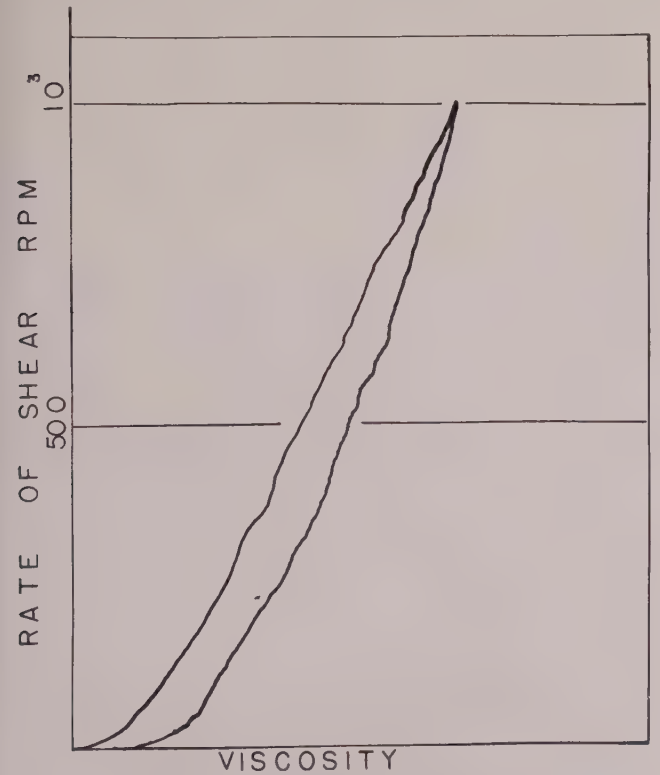

Fig. 6. Rheogram of coating formulations outlined in Table III

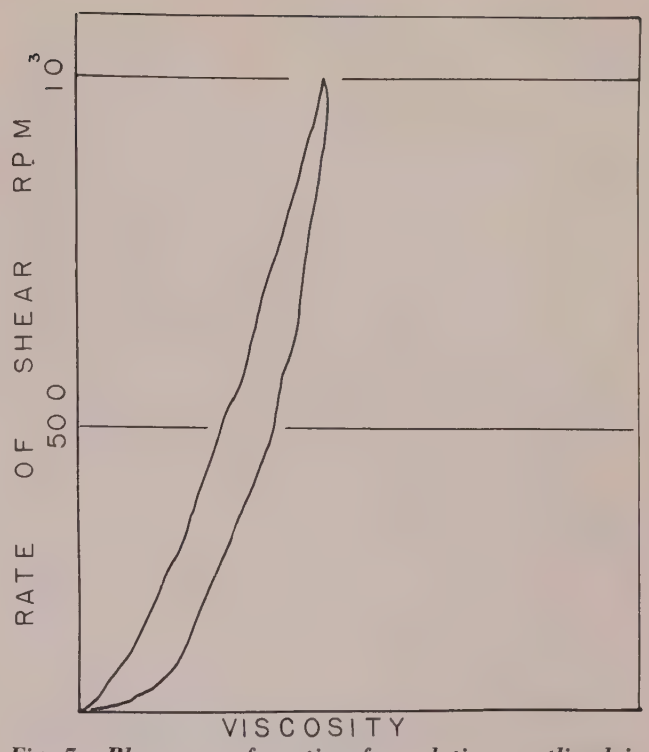

Fig. 7. Rheogram of coating formulations outlined in Table III

controlled by altering the percentage of cationic treatment on the starch or varying the percentage of cationic surfactant added to the coating.

In actual practice modifying the coating starch with stearates will yield a two- to threefold increase in viscosity while the cationic modifications that were evaluated in this work produced a five- to eightfold increase.

Water Retention

The water retention developed for each starch system

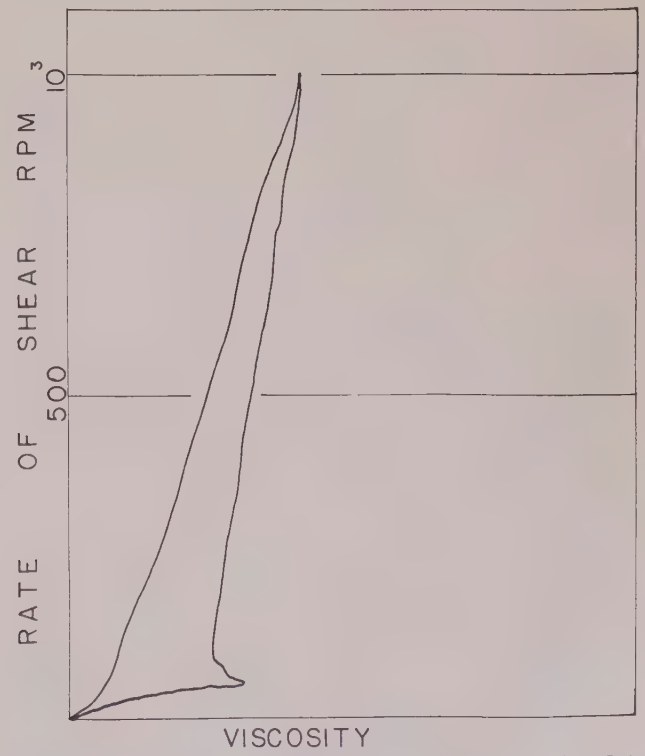

Fig. 8. Rheogram of coating formulations outlined in Table III

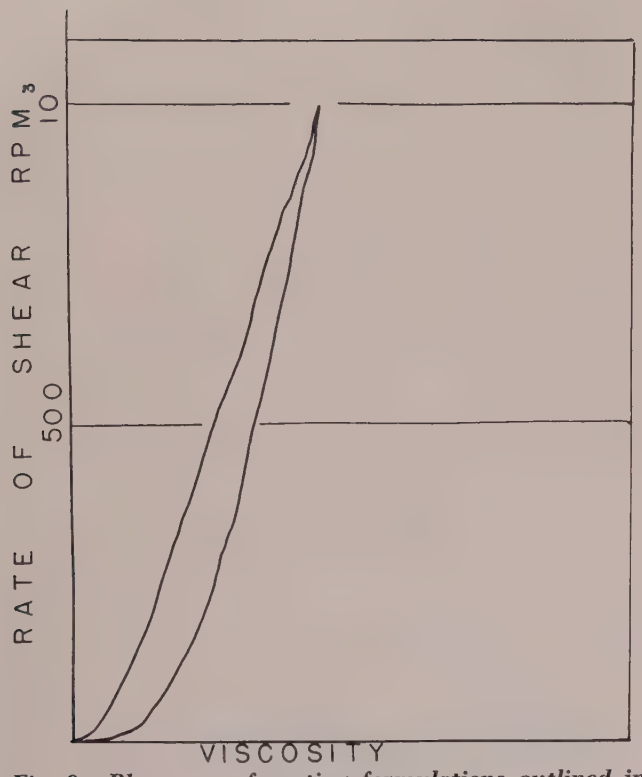

Fig. 9. Rheogram of coating formulations outlined in Table III

is reported in Fig. 2 as a function of the adhesive ratio (per cent adhesive on 100 parts of clay). The comparisons noted are the data for the base starch; cationic starch of similar viscosity, a combination of 4 parts base starch and 1 part cationic starch, and the base starch to which a surfactant has been added. The increase in water retention of the cationically modified coatings compared to the base-starch bound coating are due mainly to their higher coating color viscosity. However, this increase in water retention is not proportional to the viscosity increase (*5*). Dividing the viscosity (U) by water retention (WR) a value K_1 is obtained which is relatively constant for the base starch, but for the other examples, this value increases rapidly as the binder ratio and the resultant viscosity increase (see Table II). It is interesting to note that a value K_2 resulting from dividing the logarithm of the viscosity by water retention is much more constant for the three systems outlined. It can be seen that the viscosity curves of these systems plotted logarithmically versus adhesive ratio are straight line functions (Figs. 3, 4, and 5). Further comparisons of the K_1 and K_2 values should be investigated.

As would be expected, there appears to be a more definite "false viscosity" imparted by the cationic materials as evidenced by their greater deviation in the factor $U/WR = K_1$. This is corroborated by the rheology characteristics which show a greater degree of breakdown with a smaller area under the curve.

Rheology

The high shear flow characteristics of coatings containing various starch systems were examined on the Hercules high shear viscometer (using the "A" spindle). Five typical formulations are outlined in Table III and the rheograms developed are illustrated in Figs. 6–10.

Assuming that the basic requirement for any machine operation can be depicted by a general high shear viscosity curve it follows, that any desired coating adjustment such as reduction in solids, to obtain lower coating weight, should be compensated for by a formulation change to obtain similar rheology. This we believe, has been a major problem in developing coating varia-

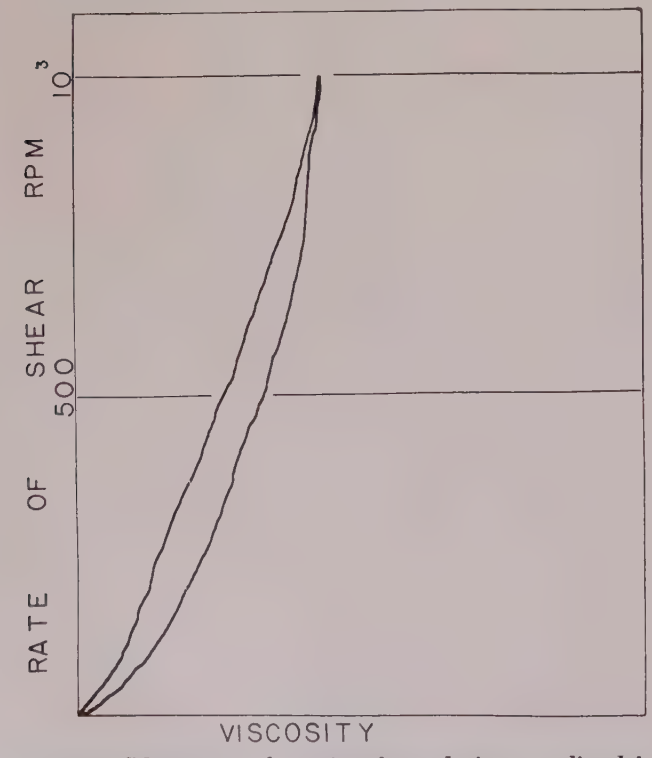

Fig. 10. Rheogram of coating formulations outlined in Table III

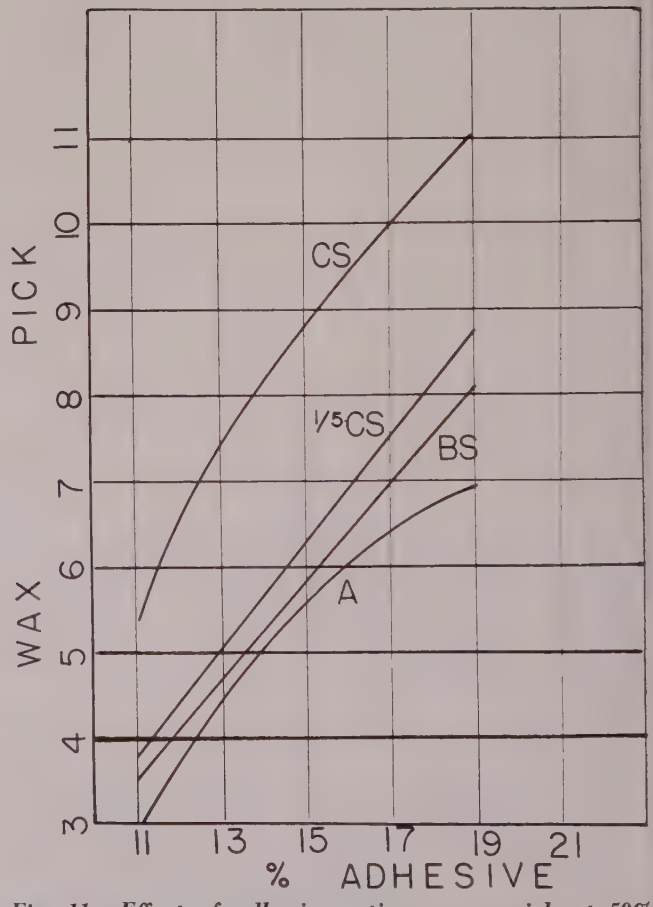

Fig. 11. Effect of adhesive ratio on wax pick at 50% solids

tions to permit the successful application of lower coat weights and in many instances has lead to the inclusion of viscosity modifying agent.

Coatings which were cationically modified indicated their ability to replace at reduced solids, the standard, base starch coatings prepared at higher solids. This

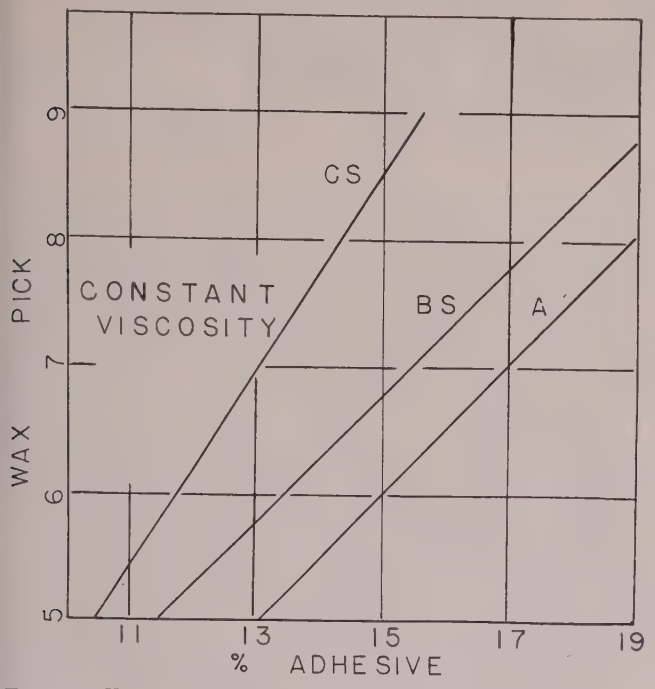

Fig. 12. Effect of adhesive ratio on wax pick at a constant viscosity of 5000 cp.

can be observed by comparing Figs. 7 and 9 with Fig. 10 and noting their formulations as outlined in Table III. In other words, no appreciable change in the machinery characteristics would be expected and while operating under set conditions, a reduction in coat weight could be accomplished by employing a cationic modification. The rheology produced by cationic additives and cationic starches were very similar throughout this work. However, as will be outlined below, a lower coating strength characteristic was generally produced by the cationic surfactant. Furthermore it was generally observed, and was observed in comparison with formulations represented in Figs. 9 and 10, that the cationic starch permitted not only a reduction in total solids but also a reduction in binder-to-pigment ratio, not obtainable with the surfactant.

As seen in Figs. 6 and 8 where the base starch and cationic starch are compared in formulations at higher solids, the cationic starches impart a greater rate of breakdown at high shear than can normally be obtained with a standard starch. However, the formulation containing the cationic starch is at a lower solids (56% compared to 62%) and the higher degree of breakdown may again relate to its "false" base viscosity and lend support to the theory that a given coating color will reduce to a common viscosity level proportionate to the solids and basic adhesive concentration if a sufficiently high rate of shear is applied. This was evidenced in this work where similar adhesive systems were utilized and is deserving of future investigation.

Pick Resistance

Figure 11 outlines the wax pick resistance of the four systems at adhesive ratios varying between 13 and 19% at 50% coating solids. It can be readily seen that the cationic, starch based coating and the surfactant treated coating exhibit widely different effects in this respect. The cationic surfactant in spite of improving water retention indicated a deleterious effect on pick resistance while the cationic starch showed very significant improvements. Blending the cationic starch with the standard coating starch enhanced pick resistance relative to the amount replaced. Twenty per cent replacement of the base starch represents the first level at which a significant strength was noted. The effect of the cationic starch on pick strength was also compared to the effect of the standard starch with and without addition of surfactants utilizing a coating color viscosity of 5000 cp. as the control and varying solids and adhesive ratio.

Figure 12 illustrates the effectiveness of the cationic starch under these conditions. While the magnitude of its improved pick strength might not seem so significant in comparison to the previous graph, it is important to note the difference in solids obtained within the represented portion of the graph. For example, between graph limits the coating color solids of the cationic starch at 5000 cp. was 48 to 52% while for the same limits the solids for the standard starch was 57 to 62%. Possibly, the increased slope of the cationic starch curve in Fig. 12 is due to the chemical affinity of the amine group, not exhausted by the pigment, to the cellulose fiber. It seems significant especially when considering an approach to lightweight coating, that the cationic starch at the same binder level and coating color viscosity may yield a two to three wax pick higher strength at approximately 10% lower coating solids.

CONCLUSION

Cationic starches or surfactant additives represent another method of obtaining increases in coating viscosity and subsequent improvements in coating rheology.

By varying the degree of cationic content of the coating wide fluctuations in viscosity may be obtained which can be of excellent benefit where coating color solids are drastically reduced.

The cationic starches offer the most important additional benefit of producing high strength coatings when compared as direct replacements for currently utilized preconverted products. This increase binding strength will allow reduction of starch binder while maintaining coating strength. Since it is generally felt that small reductions in total binder will yield significant improvements in coating brightness and opacity, the utilization of cationic starch binders will be investigated in the area of lighter weight publication coatings.

Future work on these binders will include the use of pilot coating, calendering and printing equipment to determine their comparative effect on the optical, strength, and printing characteristics of machine coated and calender papers.

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The Determination of Fiber Length Distribution in Connection with Beating Research

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Shortening of the fibers is one of the results of beating pulp. The cutting can be followed by observation of the changes taking place in the fiber length frequency distribution curve. Fiber length measurements can be conveniently carried out with semiautomatic fiber length recorders. Throughout this investigation, frequency distribution by length has been used. The distribution curve representing unbeaten pulp varies considerably, depending upon the species of wood and the pulping conditions. Beating tests were carried out in various well-known laboratory beaters, using some typical pulp samples made from Finnish species of wood. In fiber length distribution, the most conspicuous difference between softwood and hardwood pulp is that the distribution curve of commercial hardwood pulp is more or less Gaussian, with a small secondary distribution maximum for short fibers. The shape of the curve, to a great extent, remains intact through beating, although there is a tendency for the short fiber distribution to grow. Softwood pulp, however, has a broader distribution, and the cutting of the fibers rapidly shows up as an increase in the amount of short fiber material. Sulfate pulp seems to be more resistant to cutting than sulfite pulp. The strong cutting action exercised on softwood sulfite is very clearly seen when a fraction of uniform length is beaten separately. A ball mill, such as the Lampén mill, does not as a rule cut fibers to the same extent as beaters equipped with knives. When pulps of two different qualities are beaten together, the cutting action of the beater on one of the components in the mixture is dependent upon the presence of the other component.

When fibers pass through a beater, they experience several changes in their physical appearance. There are several terms used to describe the action of the beater, or more generally the action of the equipment used for the beating and refining of pulp. It is said that the beater can brush, crush, bruise, rub, cut, fibrillate, and hydrate the pulp, in addition, the beating has an influence on the flexibility and the swelling of the fibers. In general, if only the immediate results are considered, the beater performs the task of subdividing the fibers into smaller fragments, either lengthwise, crosswise, or concentrically. The properties of the beaten pulp are naturally of considerable interest, and several methods for characterizing these properties have been used. In some way or other most of them are based on the influence of the reduced dimensions of the fibers on the specific surface area of the pulp, and thereby on the various filtration resistance values of the pulp.

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The most straightforward action of the beater, however, is the cutting of pulp fibers, which simply results in a reduction of the fiber length. Observation of fiber length might therefore be one way by means of which it could be possible to follow, in a very simple and easily interpreted fashion, one aspect of the action of the beater.

The expression "fiber length" is probably more frequently and more loosely used than any other combination of two words in the paper industry. Almost every strength value is said to depend on fiber length, and fiber length is said to be influenced by most of the various steps in the pulping and papermaking process. The way of expressing fiber length varies; in some cases, statements on the influence of fiber length are based on fractionation data, sometimes on data obtained in actual measurements of length, but regrettably, often the basis is no more than a feeling that the fiber length in one instance is different from that in another.

The only unequivocal way of assessing a numerical expression for the fiber length is of course that of measuring the actual length of a sufficient number of fibers. An excellent review of various methods for carrying out this type of measurement has recently been presented by Wilson (*1*), and there is no need to go into these questions in detail.

It is sufficient to state that since fibers in a given pulp sample can be of different origin as regards the place of growth of the tree and the position in the trunk, and may have different functions in the tree, and that each fiber might have undergone different mechanical treatments in the chipping, cooking, bleaching, and stock preparation stages, it is clear that the distribution of fiber lengths in a pulp sample is far from uniform. It therefore follows that in order to get a reliable estimate of the average fiber length, not to speak of the distribution function, a large number of fibers have to be measured. It is obvious that a procedure which includes slide preparation, projection, measuring, and calculation is extremely time-consuming, and such a method does not invite large scale investigation.

During the last few years however, there have appeared some semiautomatic fiber-length recorders, which reduced considerably the time required for measuring the fibers, and for classifying and recording the results. The semiautomatic fiber-length recorder designed by v. Alfthan, and described in a paper by Ilvessalo-Pfäffli and v. Alfthan (*2*), has been used in the present investigation. The fibers are measured

manually by means of a curvimeter from a projected image of the preparation, and the recorder, receiving impulses from the curvimeter, divides the fibers into length groups at 0.2 mm. intervals. The number of fibers in each length group can be read from the appropriate counters.

Another semiautomatic instrument for fiber-length measurement has been designed in Germany, and is described in a paper by Brecht and Volk (*3*). The instrument differs from the Finnish instrument in its electrical system of length recording and classification, and in the important fact that the length interval is not fixed, but can be changed according to requirements set by the fiber length distribution. By the use of both instruments, a considerable saving in the time required for measurement has been reported, and after the fiber slide has been prepared, fibers can be measured at a rate of about 1200 per hour.

The object of the present investigation is not to find the effect of beating on the average fiber length value expressed either as the arithmetical or as the weighted average, but to follow changes taking place in the length distribution curve, and, if possible, to find what happens to certain fibers or fiber groups during beating. The results have been presented throughout in the form of frequency distribution curves by length, i.e., the total length of fibers falling within a given length group has been expressed as a percentage of the total length of all fibers measured. The "frequency" thus obtained has been plotted in a diagram against the average length of the fibers in the length group concerned, and all points have been connected by straight lines. The true distribution curve is of course a smooth curve; this can be obtained from the polygon by an infinite increase of the number of fibers measured, and decrease of the length interval.

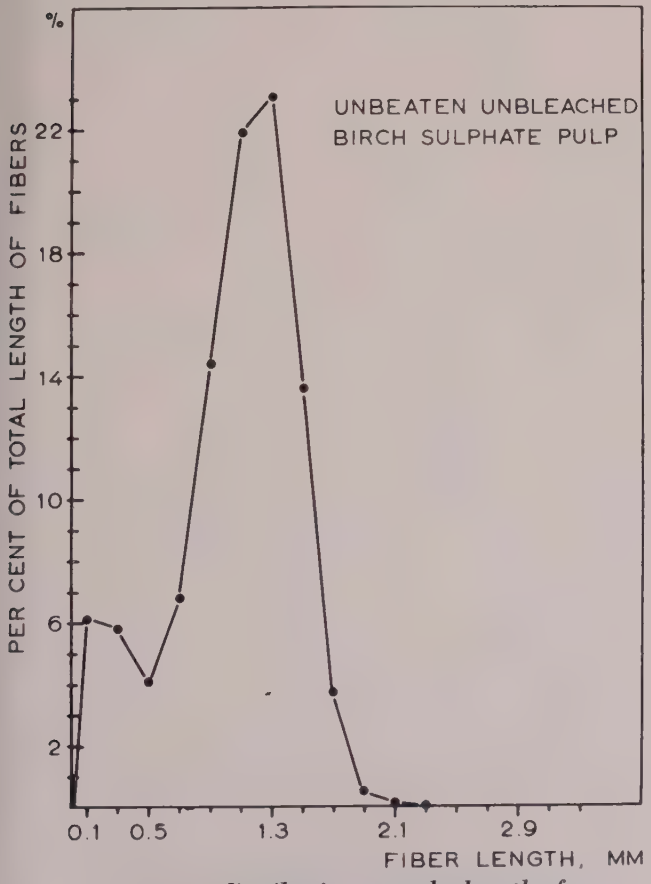

Fig. 1. Frequency distribution curve by length of an unbeaten, unbleached, birch sulfate pulp

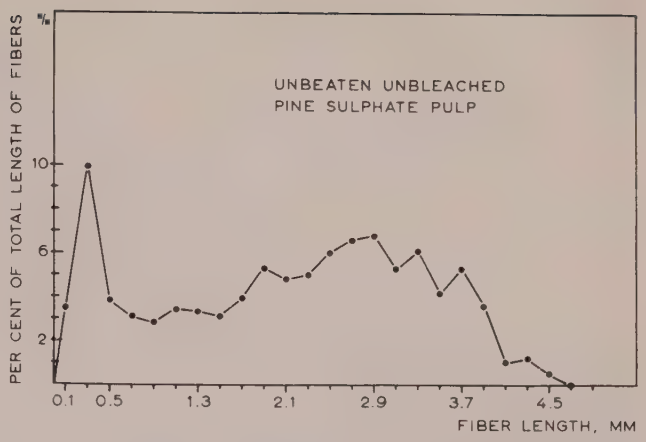

Fig. 2. Frequency distribution curve by length of an unbeaten, unbleached, pine sulfate pulp

To a considerable extent, the reliability of fiber-length measurements is dependent on the sampling and on the preparation of the fiber slide. In order to achieve a uniform and not too dense a preparation, the method suggested by Bergman and Backman was adopted (*4*). According to this method, a dyed, very dilute pulp suspension is drained in a British sheet-mold on to a hardened filter paper placed on the wire. The filter paper is then pressed against the gelatin layer of an exposed photographic plate, whereby the fibers are transferred and fixed on to the gelatin layer. As a result of the drainage from the dilute suspension, the fibers are very uniformly distributed, and the bending and twisting of fibers which occurs when a slide is prepared by evaporation is also avoided. In addition, the probability of a fractionation effect when a large amount of a fiber suspension is taken is considerably less than when only a drop is taken.

UNBEATEN PULP

Very carefully macerated wood samples, or pulp which has been specially prepared with the object of retaining the fiber length, show a more uniform fiber-length distribution than commercial pulp. Bruun and Slungaard (*5*, *6*), who measured the fiber-length distribution for a number of wood species growing in

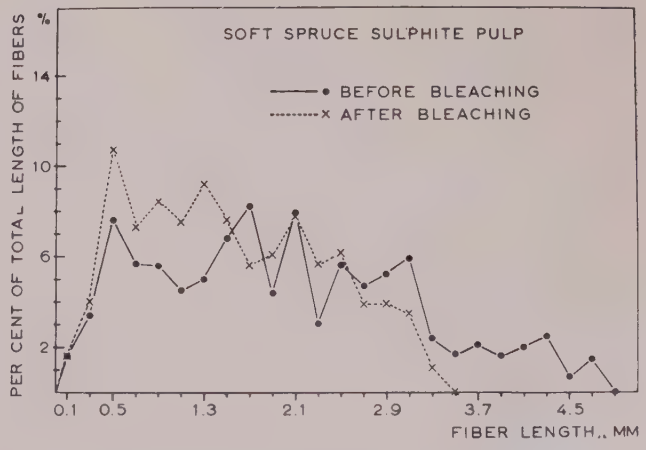

Fig. 3. Frequency distribution curve by length for an unbeaten, soft spruce sulfite pulp both before and after the bleaching

Northern Europe, found that if undamaged tracheids of spruce and pine, and undamaged libriform cells of various hardwoods are measured, the distribution could in each case be described by a normal frequency distribution curve. This is in agreement with the general rule in statistical mathematics, that if a variant (in this case the length of undamaged fibers) is influenced by a large number of independent factors, i.e., growth factors of various types, the variant is usually normally distributed.

During the whole pulping process, the wood raw material is subjected to mechanical damage, and as a result the well-defined length distribution of the virgin fibers is considerably distorted in most of the commercially available cellulose pulps even before beating. A general feature of the distribution curves for commercial pulps seems to be a certain skewness which can be interpreted as being the result of the presence of two or more distributions. This seems to be a particularly acceptable explanation in the case of hardwood pulp. There, the original normal distribution of the fiber lengths seems to have been comparatively well retained, and only a secondary distribution of short fiber material seems to have been added as a result of the pulping stage. This can be seen from Fig. 1, which gives the fiber-length distribution curve for an unbeaten birch sulfate pulp. The corresponding curve for an unbleached pine sulfate pulp, as in Fig. 2, has a marked maximum at a fiber-length of about 0.3 mm., and then a very wide range of fiber-lengths, in which can be discerned at least one, if not two separate distributions.

A very soft spruce sulfite pulp was found to change considerably in fiber-length distribution during the bleaching, and as a result the long fibers present in the unbleached pulp completely vanished, whereas the amount of short fiber increased, giving rise to the fiber length distribution of the unbeaten pulp shown in Fig. 3. It is thus evident that the various raw materials for papermaking, as they arrive in the beater room, present a wide variety of distribution patterns.

BEATING IN THE VALLEY BEATER

A number of different pulps were beaten in the Valley beater, and some of the results are discussed on the basis of the distribution curves in Figs. 4–6. The length distribution curves of an unbleached, hard

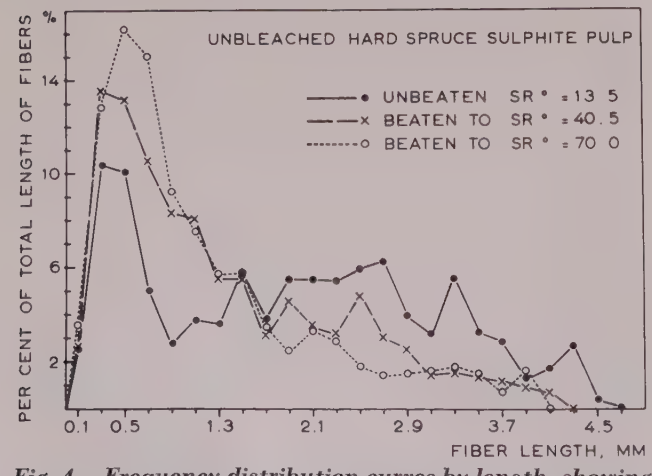

Fig. 4. Frequency distribution curves by length, showing the effect of beating in a Valley laboratory beater of an unbleached, hard spruce sulfite pulp

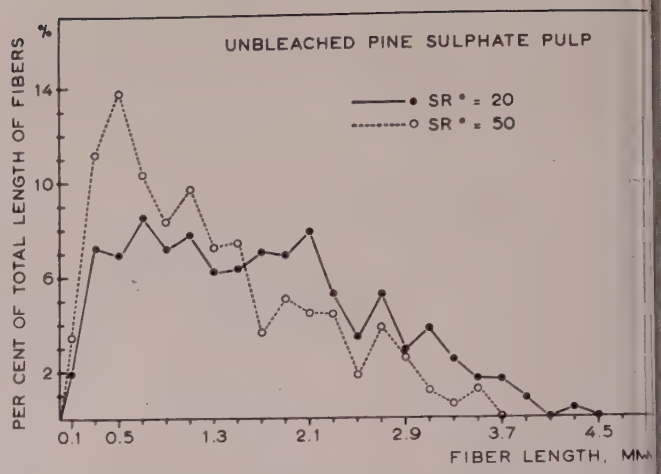

Fig. 5. Frequency distribution curves by length, showing the effect of beating in a Valley laboratory beater of an unbleached, pine sulfate pulp

spruce sulfite pulp, unbeaten and after beating to °S.-R. = 45 and °S.-R. = 70, respectively, are plotted in Fig. 4. The curve representing the unbeaten pulp has a marked maximum at a fiber length of 0.3 to 0.5 mm., while the bulk of the fibers are distributed so as to form a broad maximum at a fiber length of 2.3 to 2.7 mm. This maximum frequency decreases during beating at the same time as the largest observed fiber length decreases. The fragments formed by the cutting action of the beater on the long fibers and on fibers of medium length can then be observed as an increase in the quantity of fibers present in the shorter fiber-length groups. The largest increase is found for fibers between 0.3 and 1.3 mm. in length when going from the unbeaten pulp to a degree of beating of about

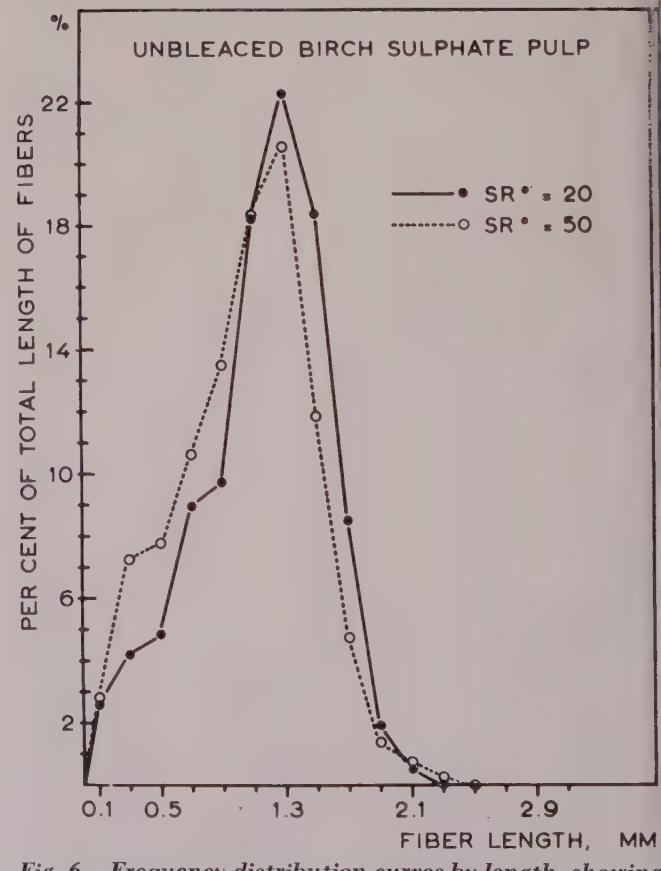

Fig. 6. Frequency distribution curves by length, showing the effect of beating in a Valley laboratory beater of an unbleached, birch sulfate pulp

40°S.-R., but if the beating is continued until the °S.-R. value of the pulp is 70, the increase is experienced by fibers having a length of 0.3 to 0.9 mm. only.

The resistance of pine sulfate fibers to cutting is somewhat better than for spruce sulfite, as seen in Fig. 5. To avoid confusion, two curves only have been plotted, representing the results for a pulp having degrees of beating of 20°S.-R. and 50°S.-R. respectively. The trend, which is the same as for spruce sulfite, shows a frequency maximum around a fiber length of 0.7 mm. which grows at the expense of the longer fibers. However, it seems as if the distribution containing the shorter fibers is broader than in the case for spruce sulfite pulp.

Using averaged length-distribution curves for a number of different pulps as a basis, Klipper (7) in an extensive investigation, found that pine sulfate pulp when beaten under conditions equal to those employed for spruce sulfite pulp retains better its fiber-length. This is in agreement with the present results.

The situation is quite different, however, when birch sulfate pulp is in question. In Fig. 6, it is seen that the distribution is very nearly Gaussian, with a small secondary distribution superimposed on the curve in the short fiber range. The main distribution, however, is very little influenced by beating, and the rapid and more or less complete destruction of the main distribution observed for softwood fibers has no counterpart in the curve showing the effect of beating of birch sulfate pulp to 50°S.-R. The frequency maximum is moved just slightly toward shorter fiber-lengths, and there is small increase in the quantity of fibers in the secondary short-fiber distribution.

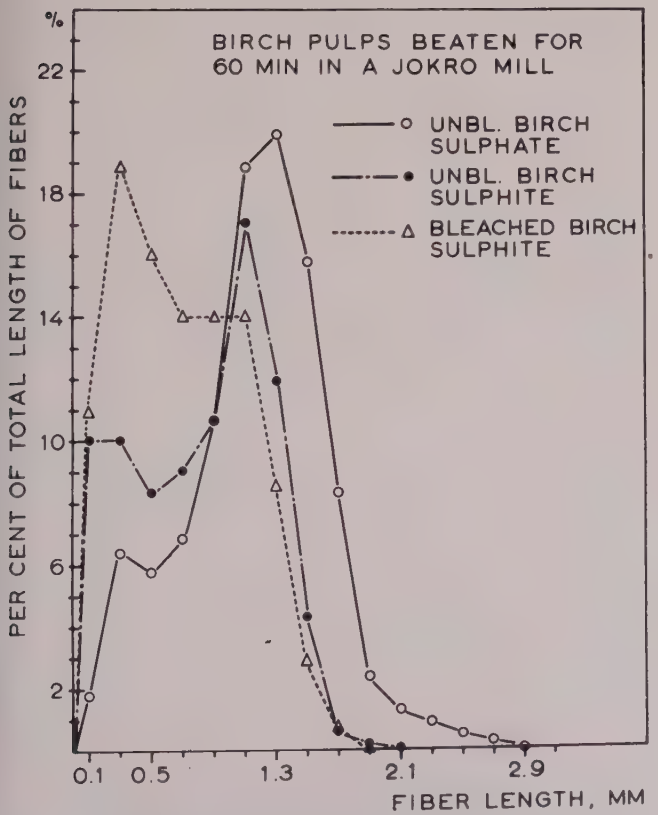

Fig. 7. Frequency distribution curves by length of three different birch pulps beaten for 60 min. in a Jokro mill

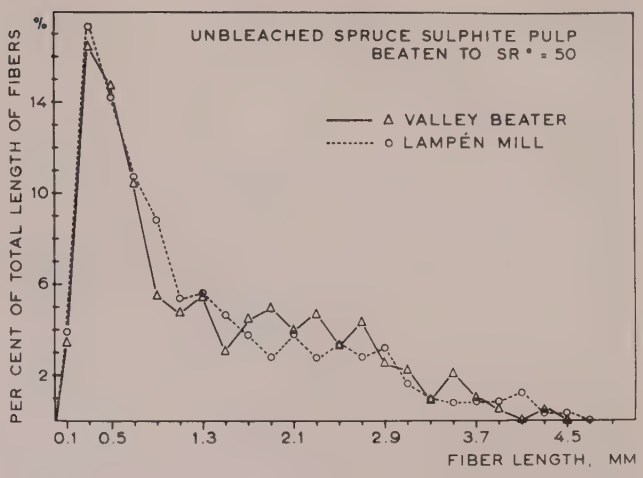

Fig. 8. Frequency distribution curves by length of an unbleached, spruce sulfite pulp beaten to °S.-R. = 50 in a Valley laboratory beater and in a Lampen mill

A COMPARISON BETWEEN BIRCH SULFITE AND BIRCH SULFATE PULP

As birch sulfate pulp reacts to beating differently from all the softwood pulps tested, a comparison between different birch pulps was indicated. Figure 7 shows the effect of a 60-min. beating in a Jokro beater on the distribution curves of an unbleached, birch sulfate pulp, and on a bleached as well as unbleached birch sulfite pulp. It is clearly evident that the unbleached sulfate pulp is the most resistant, while the bleached sulfite pulp is easily cut. The unbleached, birch sulfite pulp is considerably more resistant than the bleached pulp. There is, it is true, a difference in the degree of beating between the three pulps after constant beating time. Since it is a question of cutting, however, the chances of the fibers being cut in a given beater are dependent upon the beating time. An equal number of knife cuts thus produces most damage to bleached, and then to unbleached birch sulfite fibers. Sulfate pulp, even though it has the same chance of being struck is not cut up in the same way.

COMPARISONS BETWEEN DIFFERENT LABORATORY BEATERS

An unbleached, spruce sulfite pulp, and an un-

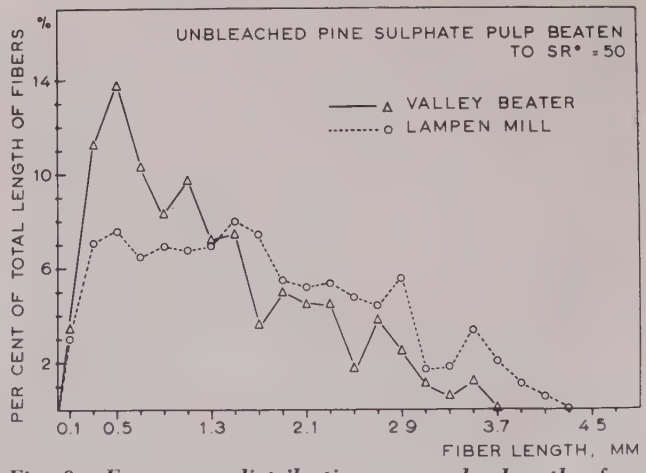

Fig. 9. Frequency distribution curves by length of an unbleached, pine sulfate pulp beaten to °S.-R. = 50 in a Valley laboratory beater and in a Lampen mill

bleached, pine sulfate pulp, were beaten in both a Valley beater and in a Lampén mill. The results are shown in Fig. 8 and 9. As a basis for comparison of the fiber-length distributions, a °S.-R. value of 50 was chosen. As can be seen in Fig. 8, the difference in fiber length distribution between the beating of spruce sulfite pulp in a Valley beater and in a Lampén mill is negligible, and can be considered as falling within the limits of error. On the other hand, there seems to be a very pronounced difference in the cutting action of these two beaters as far as pine sulfate pulp is concerned (Fig. 9). In the Valley beater, a large quantity of short fibers having a length from 0.3 to 1.1 mm. are produced. In the Lampén ball mill, however, the fibers retain their length remarkably well, and the distribution curve shows clearly that fibers ranging from 0.3 to about 2 mm. are present in each length interval in nearly equal quantities. The pine sulfate fibers thus seem to need the action of a cutting edge in order to become shortened in contrast with the sulfite pulp fibers which even by the impact of the heavy ball, are cut into shorter fragments. The same trend is clearly seen to exist also when birch sulfate pulp is beaten in the Valley beater and in the Lampén mill. In Fig. 10, the fiber-length distribution curves for samples of birch sulfate pulp beaten to 50 °S.-R. in various beaters are compared. There is a significant difference in the dominant fiber length, depending on the beater employed.

The Aylesford laboratory beater (*8*, *9*) clearly cuts the fiber more extensively than the other beaters. The dominant fiber-length is shifted through cutting in such a way that the main distribution and the distribution of short fibers nearly coincide. The two other beaters which are equipped with knives, i.e., the Valley beater and the Jokro mill, produce fiber-length distribution curves in which the secondary distribution is smaller, and is clearly distinct from the main distribution. The Valley beater seems to shorten the fibers slightly more than the Jokro mill does, when the pulp is beaten to approximately the same °S.-R. value. As the Lampén mill is a ball mill, it has, as can be expected, the least shortening effect.

BEATING OF A PULP FRACTION

Irrespective of the beater employed in the preceding experiments, the fiber-length distribution of the beaten, birch sulfate pulp was of the same general nature as that noted for the unbeaten pulp. Softwood sulfite pulp, however, has, as a rule, a broader and more irregular distribution from the beginning, and also experiences greater changes in the fiber-length distribution curve during the beating. It was therefore thought that there might be some connection between the type of distribution pattern exhibited by the pulp before beating, and the changes brought about in the distribution curve by the action of the beater. Each fiber length, when cut in a random way, produces a certain length distribution. If these partial distributions are summed up over all fiber lengths, a new total distribution is obtained, the form of which must depend on the original distribution.

A bleached, spruce sulfite pulp was therefore fractionated in a Bauer-McNett classifier, and the fraction passing screen No. 14, but retained on screen No. 20,

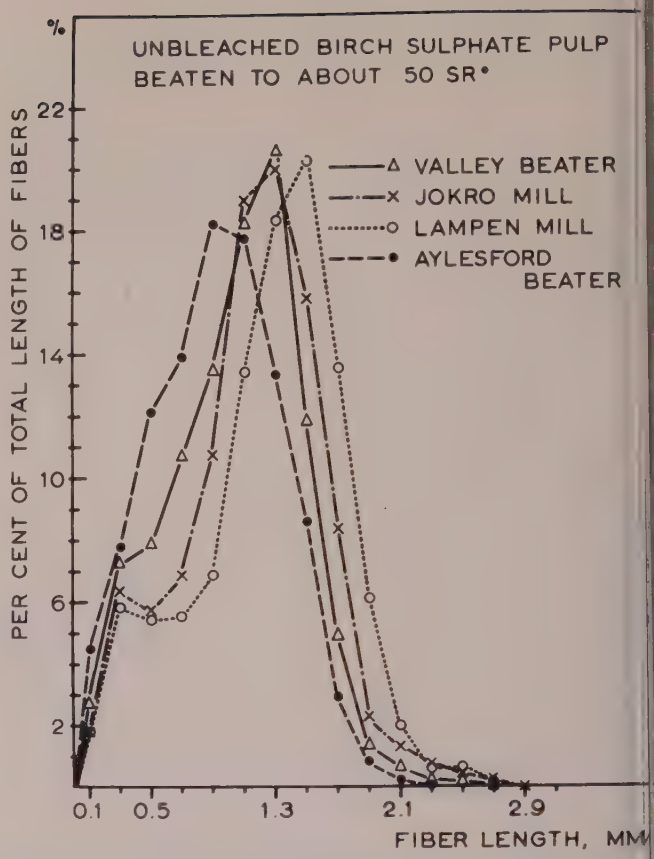

Fig. 10. Frequency distribution curves by length of an unbleached, birch sulfate pulp beaten to °S.-R. = 50 in four different laboratory beaters

was collected. To further improve the uniformity of the distribution, the fraction was re-fractionated over the same screens, and again the fraction which was retained on screen No. 20 was collected. This fraction was then beaten in the Jokro mill, and samples for fiber-length measurements were taken after 20 and 40 min. respectively. The results are presented in Fig. 11 from which it can be seen that despite the fact that the unbeaten fraction had a fiber-length distribution curve which, as in the case of whole birch sulfate pulp, resembled a normal frequency distribution curve, the development caused by beating of the fraction was exactly the same as that experienced for the whole softwood pulp. Moreover, it is found that the cutting action is very fast, and a beating time of 20 min. is sufficient to destroy almost completely the original

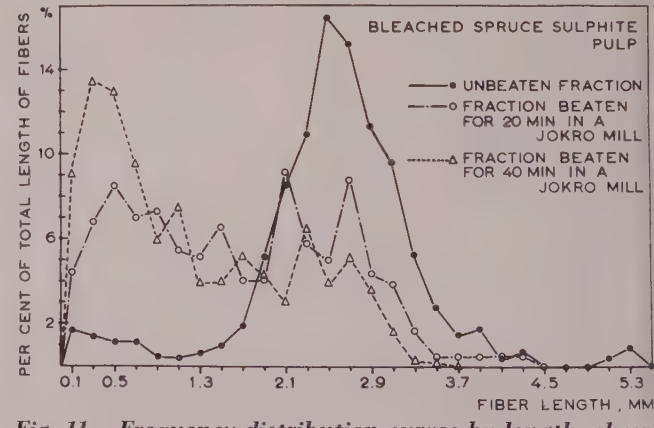

Fig. 11. Frequency distribution curves by length, showing the effect of beating of the fraction of bleached, spruce sulfite pulp passing a 14-mesh screen but retained on a 20-mesh screen

distribution pattern of the fraction. While more than 93% of the length of the fibers before beating were present in groups longer than 1.5 mm., this figure decreased to about 50% after 20 min., and to about 35% after 40 min. of beating. It is thus evident that bleached, spruce sulfite fibers are very susceptible to cutting, and that this is not connected with the distribution pattern before beating. This is a field in which additional work should be done. Fractions of various average fiber-length should be beaten, and also fractions originating from different qualities of pulp.

BEATING OF PULP MIXTURES

Every pulp is a mixture of fibers of various sizes. The individual fibers differ from each other as regards length, width, and wall thickness. When these fibers are passed through a beater or refiner, the question arises whether all fibers, regardless of size and shape, are subjected to the cutting action of the knives, or whether fibers of certain dimensions are protected from coming into contact with the beater tackle by fibers of other, logically larger, dimensions. In the case of a pulp mixture, the same question can be formulated in a slightly different way. The question is then whether two different pulp components, when beaten together, are beaten independently of each other or whether the rate of cutting of one component is influenced by the presence of the other, or vice versa. A method for investigating this problem was given in a paper by Jensen, Nordman, and Niemi (*10*).

To be able to distinguish between the components after beating, the fibers were tagged before mixing by dyeing each of them with a different dyestuff. After beating, it was thus possible to make a fiber preparation, and measure separately the length of the differently colored fibers. The results indicated that when unbleached, birch sulfite pulp and unbleached, spruce sulfite pulp were beaten together in a Jokro mill, the cutting of the birch pulp was less than if the birch pulp was beaten separately for the same length of time. Investigations of the same type were continued using various beaters and various qualities of pulp.

The results pertaining to the beating of an unbleached, birch sulfate pulp and an unbleached, pine sulfate pulp are presented in the following figures. The birch pulp was dyed with Procion Brilliant Red 5BS and the pine pulp with Procion Brilliant Blue RS (*11*), prior to beating. Subsequently, the pulps were beaten separately in the Aylesford beater at a consistency of 3%, and at a beating load of 1.1 kw. Samples for fiber-length measurement were taken after 8, 32, and 64 min. of beating. In addition, a mixture of equal parts of dyed birch pulp and dyed pine pulp was beaten under identical beating conditions, and corresponding samples were taken for fiber-length measurement. In this instance the blue pine fibers and the red birch fibers in the fiber slide were measured separately. This could be done easily owing to the distinct contrast in color between the two types of fiber.

On comparison of the fiber-length distribution curves of fibers beaten either separately or in mixture with the other component, it can be seen from Figs. 12 and 13, that the cutting is dependent on the fiber composition. In Fig. 12, the fiber-length distribution curve of the dyed, birch sulfate pulp after 32 min. of beating is presented both for separate beating of the pulp, and for beating when an equal quantity of pine sulfate pulp was present. It is obvious that the presence of pine fibers has retarded the cutting of the birch fibers to such an extent that the dominant fiber length for birch beaten together with pine is around 1.5 mm. as compared with 0.9 mm. if the birch alone is beaten for a corresponding period. From Fig. 13, however, it is evident that the pine sulfate pulp has taken the beating in the mixture, and there is a considerable difference in the distribution pattern for the two cases of mixed and separate beating. It is thus obvious that in some way the pine fibers protect the birch fibers from being cut, but that they in turn experience a more severe cutting.

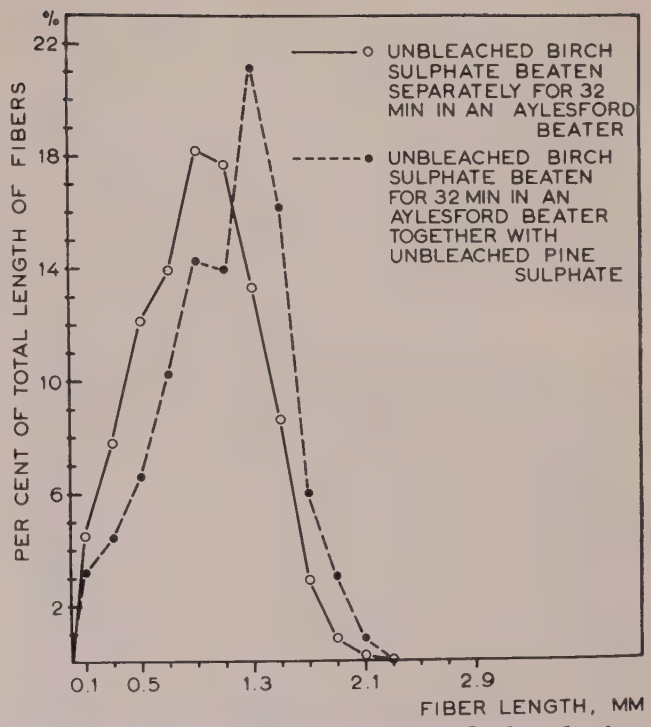

Fig. 12. Frequency distribution curves by length of an unbleached, birch sulfate pulp beaten for 32 min. in an Aylesford laboratory beater both alone and in a 50 : 50 mixture with unbleached, pine sulfate pulp

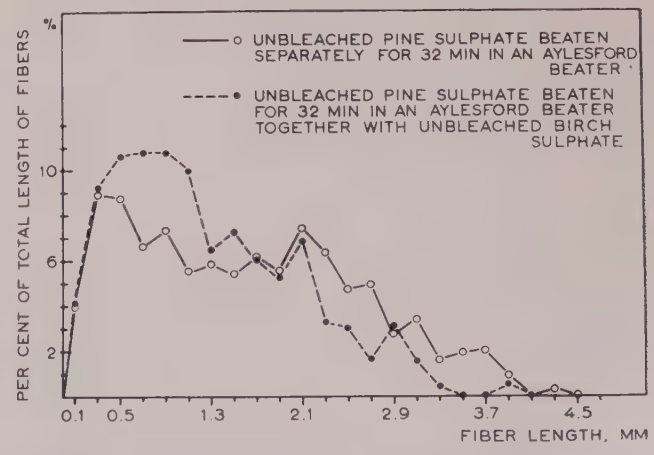

Fig. 13. Frequency distribution curves by length of an unbleached, pine sulfate pulp beaten for 32 min. in an Aylesford laboratory beater both alone and in a 50 : 50 mixture with unbleached, pine sulfate pulp

The same tendency could be observed also for the two other beating periods of 8 and 64 min., respectively. It seems, however, as if the difference between mixed and separate beating diminishes at very high degrees of beating, this no doubt being due to the fact that the cutting is very severe in both instances, and that there remains virtually only one fiber distribution, that is to say the short-fiber distribution with a dominant fiber length of well under 1.0 mm.

DISCUSSION

The fiber-length distribution curve of unbeaten pulp, compared with the corresponding curves of pulp beaten in different ways, gives an indication of the fiber shortening during beating caused by the cutting action of the beater. In studying various qualities of pulp, and their reaction to laboratory beating, it was found that sulfate pulps in general are cut less than sulfite pulps, and that hardwood pulps as a rule were found to be more resistant to cutting than were softwood pulps. As expected, the ball mill used caused less fiber cutting than laboratory beaters provided with knives. The intricate question of how individual fibers or certain fiber-length groups react to beating has so far only been touched upon. A long fraction which was beaten separately was found to lose fiber length very rapidly, in the same way as the same type of whole pulp is transformed into shorter fragments. However, the beating of pulp mixtures indicates that the various fractions are not beaten independently of each other, but that the cutting of one type of fiber is dependent on the presence of other components in the mixture. The fact that fiber-length measurements have been facilitated by the introduction of semiautomatic fiber-length recorders makes it possible to approach the beating problem from new angles. One of these might be the action of the beater on individual fibers or fiber groups.

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The Effects of Styrene-Butadiene Ratio on the Properties of Clay-Coated Paper

R. F. AVERY, A. R. SINCLAIR, and H. G. GUY

A series of latices made with the same emulsifiers and polymerized under the same conditions, varying only in styrene-butadiene ratios, have been tested as pigment binders for clay-coated paper under controlled conditions. These latices were used alone and in combination with starch and casein. In combination with casein or starch the latex was substituted for one-third of the binder. The styrene-butadiene ratio was varied from equal parts of styrene and butadiene to 90 parts of styrene and 10 parts butadiene in units of 10. These coatings were also compared with those containing only starch or only casein. Coatings were applied with the Koppers-Dilts pilot plant coater operating at a constant speed of 600 f.p.m. The coatings were applied to one side. A commercial coating raw stock of 43 lb. per ream was used throughout these tests. Coating weights varied from 6 to 18 lb. The same machine settings were used for each coating system. Wet rub resistance, pigment binding, and gloss were all found to be affected by the styrene-butadiene ratio. There were slight differences in stiffness, varnish holdout, and fold resistance. In every case the addition of the latex to the starch or casein system resulted in improved wet rub resistance. As the styrene content was increased there was a tendency for the pigment binding strength to decrease, whereas the gloss increased.

Since its introduction into the paper industry a little more than a decade ago, styrene-butadiene latex has found wide acceptance as a coating modifier and pigment binder. Most of the interest in this product has centered around those polymers ranging from 60 to 70% combined stryene in the copolymer emulsion. This range has been found to produce improvements in gloss, wet rub resistance, pigment binding, and fold endurance. It has been realized, however, that all of these properties were not at their maximum potential at any single copolymer ratio. A previous study in which the combined stryene was varied from 30 to 75% showed that some properties, viz., gloss, varnish holdout, pick and wet rub resistance vary significantly as the combined styrene content increased (*1*).

The purpose of this investigation is to examine an extended range of copolymers to determine their feasibility for use in the paper coating industry under conditions simulating mill practice with regard to the application of the coatings.

A series of copolymers were prepared ranging from 50 to 90% in combined stryene content. The poly-

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Table I. Coating Formulations

	Parts Dry	Parts Wet
A. Latex Base Coatings:		
Clay-SMC lump	100.0	..
TSPP	0.3	..
Water	..	37.0
Latex (at 50% solids)	16.4	32.8
Casein (ammonia cut at 15% solids)	1.64	10.9
Water	..	1.0
Solids, %—65.0		
Adhesive, %—18.0 based on clay solids		
Stabilization, %—10.0 based on latex solids		
B. Starch Base Coatings:		
Clay-SMC lump	100.0	..
TSPP	0.3	..
Water	..	37.0
Starch (Stayco M at 30% solids)	12.0	40.0
Latex (at 50% solids)	6.0	12.0
Casein (ammonia cut at 15% solids)	0.3	2.0
Solids, %—62.0		
Adhesive, %—18.3 based on clay solids		
Adhesive ratio—2/1 starch solids/latex solids		
Stabilization, %—5.0 based on latex solids		
C. Casein Base Coatings:		
Clay-SMC lump	100.0	..
TSPP	0.3	..
Water	..	37.0
Water (added to clay dispersion)	..	20.6
Casein (sodium carbonate cut at 18% solids)	11.4	63.4
Latex (at 50% solids)	6.0	12.0
Casein (sodium carbonate cut at 18% solids)	0.6	3.3
Solids, %—50.0		
Adhesive, %—18.0 based on clay solids		
Adhesive ratio—2/1 casein solids/latex solids		
D. Styrene/Buradiene Ratios Studied—All Latices at pH = 7–8 and 50% Solids:		
50/50 Styrene/butadiene—designated L-50		
60/40 Styrene/butadiene—designated L-60		
70/30 Styrene/butadiene—designated L-70		
80/20 Styrene/butadiene—designated L-80		
90/10 Styrene/butadiene—(non-film forming)—designated L-90		

merization process used in producing these materials was selected such that the entire series could be produced under identical conditions of agitation, emulsifier content, temperature, and stabilization requirements.

The copolymer formation in this system was such that the continuous film limit, that is the upper limit of combined stryene above which the latex emulsion would dry to a powder instead of a clear film, would be in the order of 85% instead of the normal 70%.

These latices were formulated into conventional coatings using standard mixing techniques and applied to coating raw stock using the Koppers-Dilts off-machine coater. This coater is equipped with two 14-in. diameter gate or feed rolls and an applicator and backup roll each 20 in. in diam. All four rolls have a 24-in. face and are covered with 50-durometer rubber. The two gate rolls may be adjusted for operation between one-third and three times the machine speed. The applicator roll may be varied from machine speed through a vari-sheave to approximately ± 5%. Drying is accomplished in a conveyor-equipped, hot air tunnel. Coating may be applied up to 25 lb. per side on a 20-in. web at speeds up to 1500 f.p.m.

EXPERIMENTAL MATERIALS AND METHODS

The formulations utilized in this study are shown in Table I. The coatings were produced at an adhesive level of 18% on the clay solids. The effects from styrene-butadiene substitution were studied by replacing $^1/_3$ of the natural adhesive (i.e. 6%) with latex solids regardless of styrene-butadiene ratio. The total adhesive, while being somewhat higher than average commercial practice for both the casein and all-latex binders and correspondingly lower for the starch system, allowed a uniform adhesive level to be maintained throughout the study. Coatings were prepared at the 18% adhesive level using only the starch or casein as the sole adhesive so that the changes resulting from replacing one-third of the natural adhesive with latex could be measured. The starch and casein, with no latex modification, were also formulated into coatings containing only 12% total adhesive so that the degree of improvement resulting form the addition of the latex could be measured against the improvement due to the higher adhesive level alone. The starch base coating at the 18% adhesive level was modified with 0.3% of ammonium caseinate in order to duplicate the stabilization casein added to the latex in the starch system.

The coatings were prepared by dispersing 150 lb. of clay for 1 hr. in a 40-gal. Day mixer at 74% solids. The clay slip was then diluted to 73% solids and allowed to disperse for an additional 3 hr. The base adhesive was then added to an adhesive level of 12% and mixed for an additional hour. Aliquot portions were measured into 5-gal. containers and the latex or additional adhesive was then blended in by means of a Lightnin mixer. The viscosities of these coatings (Brookfield at 20 r.p.m.) ranged from 7500 to 10,000 cp.

All of the coatings were applied using the following machine conditions:

Machine speed = 600 f.p.m.
Applicator speed = 590 f.p.m.
Gate roll speed = 780 f.p.m.

Under these conditions, coating weights from 6 to 18 lb. per ream, as shown in Table II, were applied. It may be observed that the coating weights were fairly constant within each series, but that owing to the differences in formulated solids the coating weights applied varied between series. The very high coating weight

Table II. Coating Weights Applied

Coating	Weight applied[a]
A. Latex Base Adhesive Coatings (LC-Series)	
LC-L-50	15.3
LC-L-60	15.2
LC-L-70	15.3
LC-L-80	15.2
B. Starch Base Adhesive Coatings (SC-Series)	
SC-12%—No latex	18.4
SC-L-50	13.3
SC-L-60	12.5
SC-L-70	12.9
SC-L-80	12.2
SC-L-90	12.3
SC-18%—No latex	14.7
C. Casein Base Adhesive Coatings (CC-Series)	
CC-12%—No latex	7.0
CC-L-50	6.0
CC-L-60	6.0
CC-L-70	6.2
CC-L-80	6.0
CC-L-90	6.2
CC-18%—No latex	7.4

[a] Pounds of coating applied per ream (TAPPI—25 × 40 — 500)—coated one side.

Table III. Gloss

Adhesive system	*Coating*	*Gloss*
Latex	LC-L-50	54.0
Latex	LC-L-60	55.1
Latex	LC-L-70	58.1
Latex	LC-L-80	64.6
Starch	SC-12%—No latex	59.0
Starch	SC-L-50	43.1
Starch	SC-L-60	43.3
Starch	SC-L-70	46.4
Starch	SC-L-80	49.5
Starch	SC-L-90	55.0
Starch	SC-18%—No latex	47.8
Casein	CC-12%—No latex	38.3
Casein	CC-L-50	25.0
Casein	CC-L-60	26.9
Casein	CC-L-70	27.8
Casein	CC-L-80	28.6
Casein	CC-L-90	29.4
Casein	CC-18%—No latex	28.4

produced by the starch adhesive system at the 12% adhesive level is believed to result from this coating being somewhat dilatant at high shear.

Samples of the coated paper were obtained in such a manner that no two samples came from the same position across the web nor in the length of one complete revolution of the applicator roll. A total of 24 samples were obtained from each run. The samples were supercalendered five nips at a pressure of 1800 lb. per lineal inch using an unheated calender. After supercalendering, the samples were placed in a standard conditioning room where all testing was performed.

Testing of the samples was performed as follows:

Gloss	75° Gardner glossmeter
Smoothness	Gurley-Hill "S-P-S"
Brightness	"Color Eye" Instrument-Development Lab.
Pick resistance	I.G.T. printability tester
Wet rub	Finger rub and modified Taber abrader
Gloss ink holdout	K and N ink brightness decrease
Crease resistance	Laboratory fabricated
Stiffness	Clark softness tester
Blocking	Constant humidity chambers

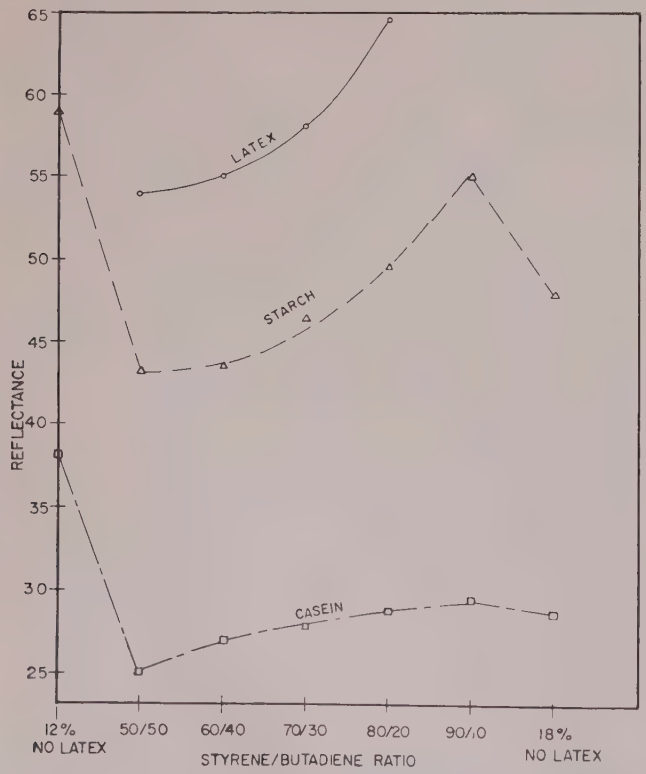

Fig. 1. Effect of styrene-butadiene ratio on gloss

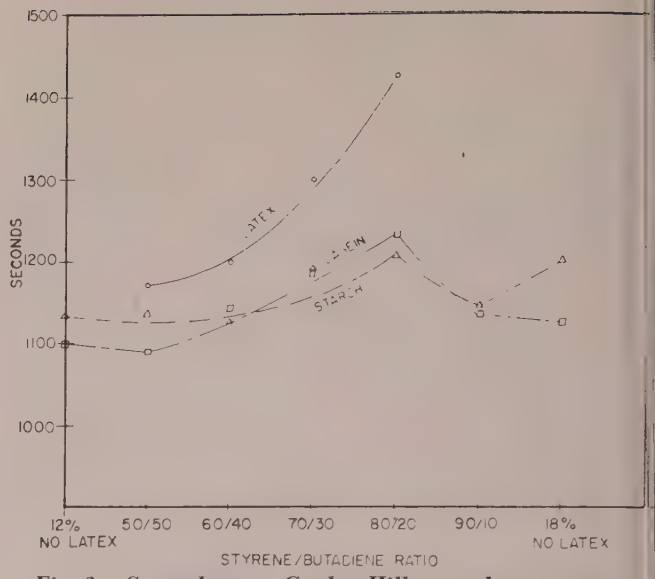

Fig. 2. Smoothness—Gurley Hill smoothness tester

Gloss—TAPPI Standard T 48051

A Gardner glossmeter equipped with a 75° head was used to determine the gloss of each sample. The gloss of all three types of coatings was found to increase with increasing styrene-butadiene ratio. The casein base coatings showed the least response in this respect, while the latex base coatings were the most significantly changed (Table III and Fig. 1).

Smoothness—TAPPI Standard T 479 sm-48

A standard Gurley-Hill smoothness tester was employed for this test. The smoothness is measured by determining the time, in seconds, for 50 cc. of air under constant pressure to pass between surfaces of the coated paper. A sheet having a smoother surface would thus produce a higher result than one with a correspondingly rough surface.

These results are presented in Fig. 2. The higher degree of smoothness exhibited by the higher combined styrene content latices is probably due to their greater degree of thermoplasticity and their correspondingly lower degree of elasticity. Thus while being somewhat

Table IV. Smoothness and Crease Resistance

Adhesive system	*Coating*	*Smoothness, sec.*	*Crease resistance*		
			Scoring	*Folding*	*Average*
Latex	LC-L-50	1270	9	9	9.0
Latex	LC-L-60	1300	9	9	9.0
Latex	LC-L-70	1400	8	9	8.5
Latex	LC-L-80	1525	5	7	6.0
Starch	SC-12%—No latex	1235	1	3	2.0
Starch	SC-L-50	1235	7	9	8.0
Starch	SC-L-60	1225	7	8	7.5
Starch	SC-L-70	1290	7	8	7.5
Starch	SC-L-80	1315	7	7	7.0
Starch	SC-L-90	1245	7	7	7.0
Starch	SC-18%—No latex	1300	3	6	4.5
Casein	CC-12%—No latex	1200	3	7	5.0
Casein	CC-L-50	1190	9	9	9.0
Casein	CC-L-60	1240	9	9	9.0
Casein	CC-L-70	1280	9	9	9.0
Casein	CC-L-80	1300	9	8	8.5
Casein	CC-L-90	1235	7	7	7.0
Casein	CC-18%—No latex	1225	6	7	6.5

Table V. Brightness and Gloss Ink Holdout

Adhesive system	*Coating*	*Brightness*	*Brightness decrease, K and N ink*
Latex	LC-L-50	80.7	23.4
Latex	LC-L-60	81.0	24.0
Latex	LC-L-70	80.8	24.5
Latex	LC-L-80	81.0	31.0
Starch	SC-12%—No latex	83.7	44.3
Starch	SC-L-50	81.5	27.3
Starch	SC-L-60	81.5	29.5
Starch	SC-L-70	82.0	30.8
Starch	SC-L-80	81.0	33.5
Starch	SC-L-90	82.0	34.5
Starch	SC-18%—No latex	82.3	36.3
Casein	CC-12%—No latex	79.5	41.1
Casein	CC-L-50	82.0	34.0
Casein	CC-L-60	82.5	33.6
Casein	CC-L-70	82.0	33.1
Casein	CC-L-80	82.3	33.8
Casein	CC-L-90	82.3	33.8
Casein	CC-18%—No latex	82.5	39.0

more difficult to deform in calendering than the more elastic lower styrene latices, they are more capable of being permanently set in whatever degree of deformation the calender is capable of imposing. It is believed that the pressures encountered in the normal supercalendering operations are more than sufficient to produce some degree of deformation in all of these polymers although the drop-off in smoothness of the 90% combined stryene coatings may be due to their greater resistance to deformation. These results also appear in Table IV.

Brightness—Tappi Standard T 452 m-58

The brightness of each coating was determined. No significant differences were found within the series, as shown in Table V.

Pick Resistance

The pick resistance of these coatings was determined by means of the IGT printability tester. In this test a metered amount of an IPI testing tack graded ink is applied uniformly to the surface of a printing disk. This disk is then placed in contact with the surface of the coated paper sample at normal printing pressures. From the point of initial contact the disk then undergoes a uniform acceleration from zero to 650 f.p.m. The coating is examined and if picking has occurred, the speed at which the picking is first observed is recorded as the picking point of that ink grade. These values are shown in Table VI.

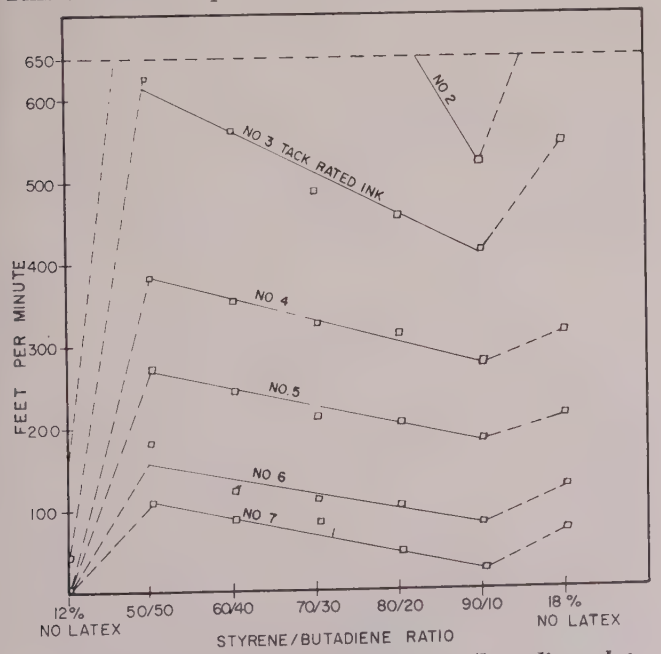

Fig. 3. Pick resistance—casein-styrene/butadiene latex combinations

Table VI. Printability Picking Resistance—IGT

Adhesive system	*Coating*	*Initial picking point (tack graded inks), f.p.m.* 2	3	4	5	6	7
Latex	LC-L-50	None	None	610	460	320	150
Latex	LC-L-60	None	None	580	500	200	60
Latex	LC-L-70	None	630	450	390	140	20
Latex	LC-L-80	500	390	280	200	90	0
Starch	SC-12%—No latex	30	0	0	0	0	0
Starch	SC-L-50	None	620	420	300	110	0
Starch	SC-L-60	None	580	410	250	100	0
Starch	SC-L-70	615	460	280	190	30	0
Starch	SC-L-80	440	260	130	85	0	0
Starch	SC-L-90	215	110	40	20	0	0
Starch	SC-18%—No latex	310	180	100	50	20	0
Casein	CC-12%—No latex	160	40	0	0	0	0
Casein	CC-L-50	None	625	380	270	180	105
Casein	CC-L-60	None	560	350	240	120	85
Casein	CC-L-70	None	485	320	210	110	80
Casein	CC-L-80	None	450	310	200	100	40
Casein	CC-L-90	515	410	270	180	80	20
Casein	CC-18%—No latex	None	540	310	210	120	70
Raw stock	...	None	None	420	280	170	70

It may be seen from Fig. 3 that in the casein-based system the use of a latex having a combined styrene content falling between 60 and 70% would essentially duplicate the binding power of the casein alone at the 18% adhesive level. It is also to be observed that the use of a polymer containing 50% combined styrene produces pigment binding in the order of $1^1/_3$ times as great as the casein.

Of interest are the binding powers exhibited by the polymers of higher styrene content. It would seem that the ability of a copolymer latex to bind pigment would be relatable to its ability to form a continuous film by fusion upon drying. In this series of latices the 90% combined styrene copolymer produced only a crumbly powder upon drying. This powder is not unlike a soft pigment with respect to particle size and dispersability. It was felt, therefore, that upon being added to a base adhesive of 12% casein, this material would produce an adhesive level equivalent to that obtained by adding 6% additional pigment to that system. It was found, however, that the pigment binding level produced by this copolymer did not fall below that of the 12% casein adhesive. Instead, it produced a coating more comparable to those with 18% casein in pick resistance.

The pick resistance of the 18% casein adhesive system was found to be proportionately greater with the lower tack inks than those modified with latex. The reason for this phenomenon is not known, but it is believed worthy of further study.

In the starch-based adhesive system, Fig. 4, it may also be observed that improved pigment binding is obtained from all of the latices employed. The combined styrene content which would be equivalent to the 18% starch adhesive system alone would appear to be in the range of from 80 to 90% in this series. Again, the latex

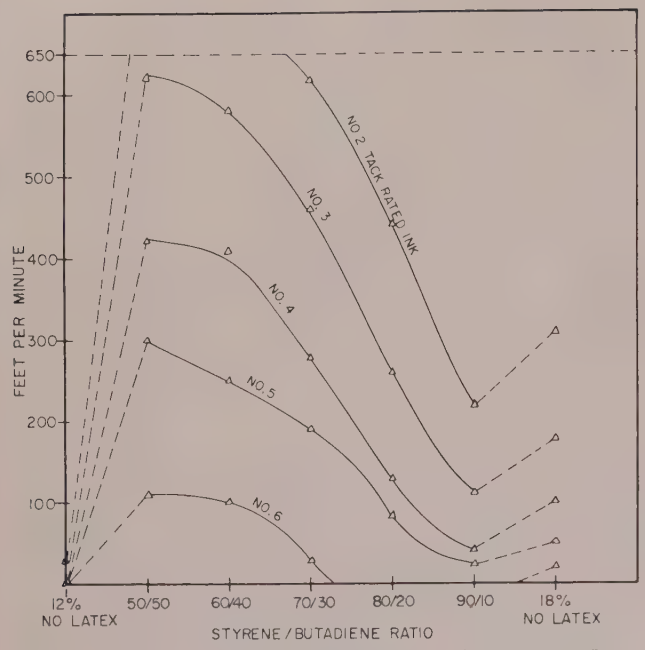

Fig. 4. Pick resistance—starch-styrene/butadiene latex combinations

containing a polymer with a 50/50 styrene-butadiene ratio gave the greatest pick resistance.

The use of an all latex binder system, Fig. 5, was found again to produce the greatest pick resistance obtainable from the latices of lower styrene content. The differences in pigment binding strength between the various styrene-butadiene ratios rested were magnified. Thus, the coating produced with the 90% combined styrene content latex was unable to be supercalendered owing to offset of some of the coating to the metal roll from the paper.

In all of the coatings, the highest pick resistance was obtained at the lowest styrene content, that is 50%, but it is significant that all of the latices evaluated were found to improve the pigment binding ability of the base adhesive. None of the latex modified coatings picked at as low a level as the 12% base adhesive.

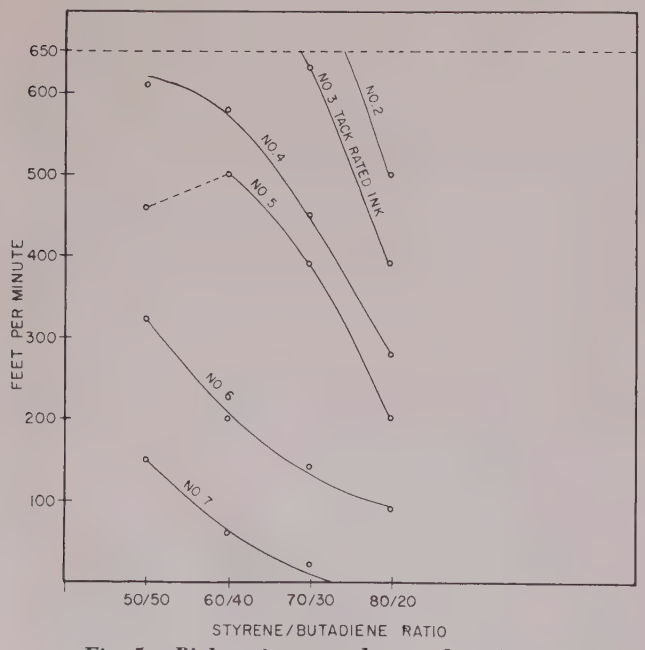

Fig. 5. Pick resistance—latex sole adhesive

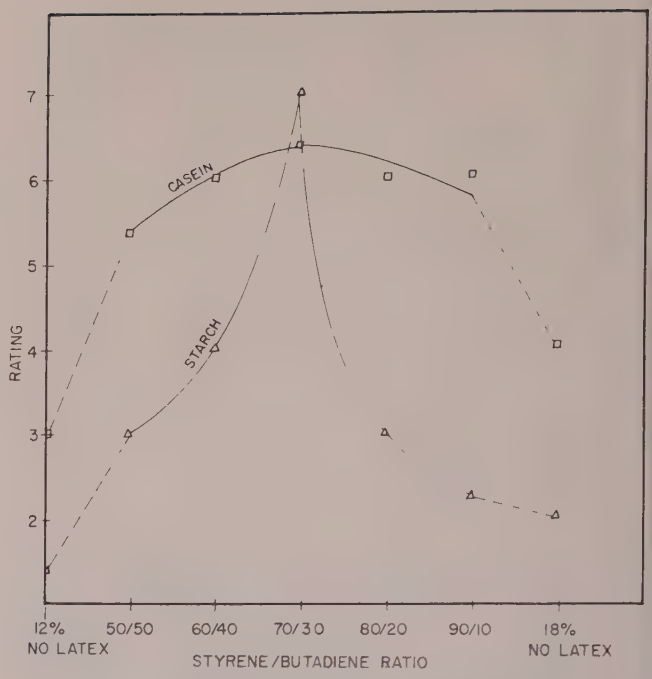

Fig. 6. Wet rub resistance—finger rub test

Wet Rub Resistance—TAPPI Routine Control RC-184, 185

Two separate tests were performed in order to evaluate the wet rub resistance of the coated paper samples. The first was the standard finger rub test (RC-185). In this test a small amount of water is placed near one edge of the sample and the tester's finger is drawn through the water over the edge of the coating and onto a piece of dark paper. Enough water is used so that the same spot may be thus rubbed at least eight times. The coated sheet is moved slightly to the side between each successive rub so that the next rub is onto a

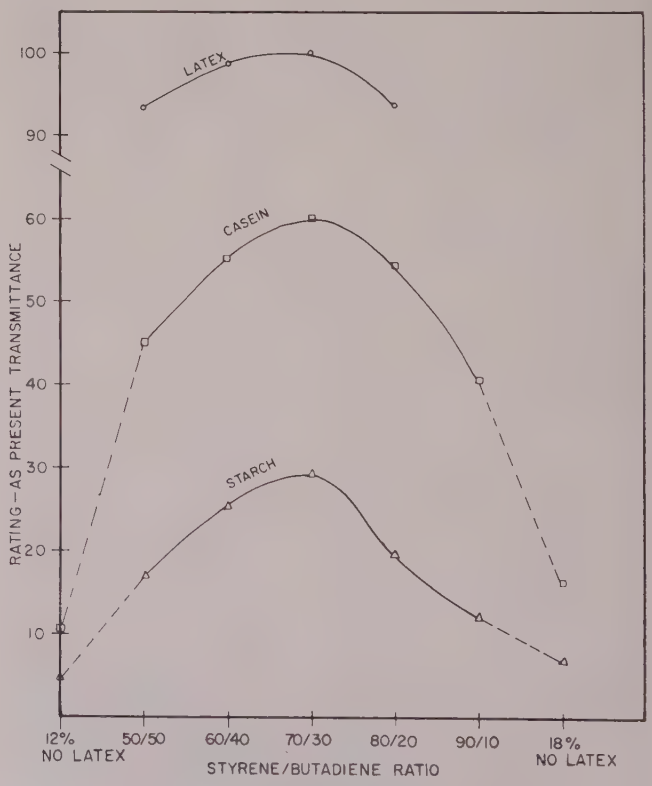

Fig. 7. Wet rub resistance—Taber abrasion test

freshly exposed area of the dark backup sheet. The water thus rubbed onto the dark sheet is then observed visually for evidence of coating which has been transferred by the rubbing action. The value assigned to each coating is that corresponding to the number of strokes required to produce the first evidence of coating rubbed off.

The second test (RC-184) was performed using a modified Taber abrader tester. The normal abrasive wheels are removed and a 1-in. paint brush is substituted in their place. The brush is balanced so that it exerts a pressure of 100 g. upon the surface of the sample.

The samples are trimmed to $4^3/_{16} \times 4^3/_{16}$ and mounted on special backup mounts, supplied by the Taber Instrument Corp. These mounts have one surface treated with a pressure sensitive adhesive to facilitate sample mounting and the other side is provided with space for sample and test identification.

After the sample is placed on the tester and the brush lowered to the paper surface, 10 ml. of water are added from a hypodermic syringe and simultaneously the machine is started. After 50 revolutions, the test is stopped and the brush carefully rinsed into the sample retainer dish. All water in the dish is then rinsed into a 100-ml. volumetric flask and additional water is added to bring the total dilution to 100 ml. The diluted washings are then measured for turbidity using a 4250 A filter on a standard Beckman spectophotometer. The results are expressed as per cent transmission. Thus, a coating exhibiting the greatest resistance to wet rub will have the highest value.

The results of these two tests are shown in Fig. 6 and 7. It may be seen that using the finger rub test, all of the latex-based coatings produced ratings of greater than eight strokes. The use of the modified Taber tester produced relative numerical values for all coatings except for that using the 70% combined styrene content which came out 100+. In all cases the wet rub resistance passed through a maximum at 70% styrene content. This result is contrary to previous reports. It has been duplicated in both casein and starch systems and would appear to be logically correct when the properties of the copolymer itself are also considered. At 70/30 this polymer forms a tough, flexible, abrasion resistant film. It is again found that the nonfilm-forming latex containing 90% combined styrene has a positive effect upon the quality of the coating, producing better wet rub resistance than the adhesive containing no latex. Table VII presents a summary of these results.

Gloss Ink Holdout—TAPPI Routine Control RC-19

The decrease in brightness resulting from applying the standard K and N varnish ink test was measured. In this test a smear of a colored varnish-base ink is placed on the surface of the coated paper and allowed to remain for 2 min. The surface is then wiped clean of all ink which has not been absorped into the coating and the coating is observed for the intensity of the color remaining. Since any ink absorbed would decrease the brightness of the paper in proportion to its amount, the decrease in brightness would be least for those coatings having the greatest degree of varnish ink holdout.

Table VII. Wet Rub Resistance

Adhesive system	*Coating*	*Finger rub, av.*	*Wet Taber abrader transmittance, %*
Latex	LC-L-50	>8	92.8
Latex	LC-L-60	>8	99.0
Latex	LC-L-70	>8	100+
Latex	LC-L-80	>8	93.2
Starch	SC-12%—No latex	1.3	3.8[a]
Starch	SC-L-50	3.0	17.3[a]
Starch	SC-L-60	4.0	25.2[a]
Starch	SC-L-70	7.0	28.7[a]
Starch	SC-L-80	3.0	19.5[a]
Starch	SC-L-90	2.2	13.2[a]
Starch	SC-18%—No latex	2.0	17.5[a]
Casein	CC-12%—No latex	3.0	10.2
Casein	CC-L-50	5.3	45.0
Casein	CC-L-60	6.0	55.0
Casein	CC-L-70	6.3	60.0
Casein	CC-L-80	6.0	44.2
Casein	CC-L-90	6.0	31.1
Casein	CC-18%—No latex	4.0	16.7

[a] Diluted to 200 instead of 100 ml.

It may be seen in Fig. 8 that as the combined styrene content of the latices increases, the varnish holdout decreases in both the starch adhesive system and the all-latex binders. This tendency is not evident in the casein adhesive system. Although not as unexpected in this test as in pick resistance, it may be again observed that the varnish holdout ability of the coatings containing the 90% combined styrene latex is better than the 12% adhesive, either starch or casein. These data are shown in Table V.

Crease Resistance

Two different tests were utilized in the measurement of the crease resistance of the coatings. In the first test, the sheets were folded 180° in each direction for a total of five times over a $^1/_{32}$-in. sheet of steel placed at a distance of $^1/_2$-in. from the fold. Several thicknesses of paper were placed over the fold and a weight of 1 kg. per in. was then passed over the protective paper for two back-and-forth strokes before the fold was reversed.

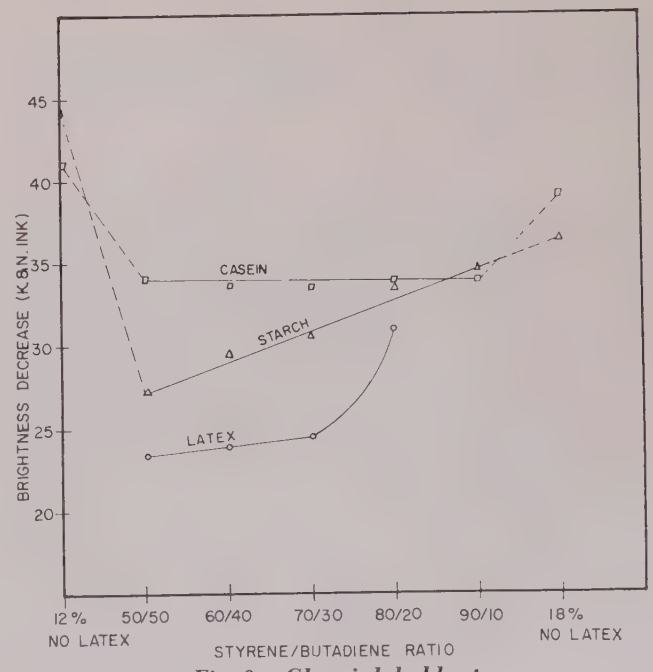

Fig. 8. Gloss ink holdout

The second test consisted in forming the initial fold using the same procedure as in the first test but then removing the test specimen from the holder and applying the weight directly on the fold for two strokes. Two complete folds of 180° in each direction were made for this test.

Each sheet was then examined under suitable magnification and rated for resistance to cracking, rupture, and flaking. A numerical system was used; e.g., complete cracking was assigned zero points, and no cracking was assigned three points. In this manner each sample could accumulate a total of nine points for each of the two test procedures.

Figure 9 presents the average results obtained from these two tests. As would be expected the latex containing 50% combined styrene exhibited the greatest

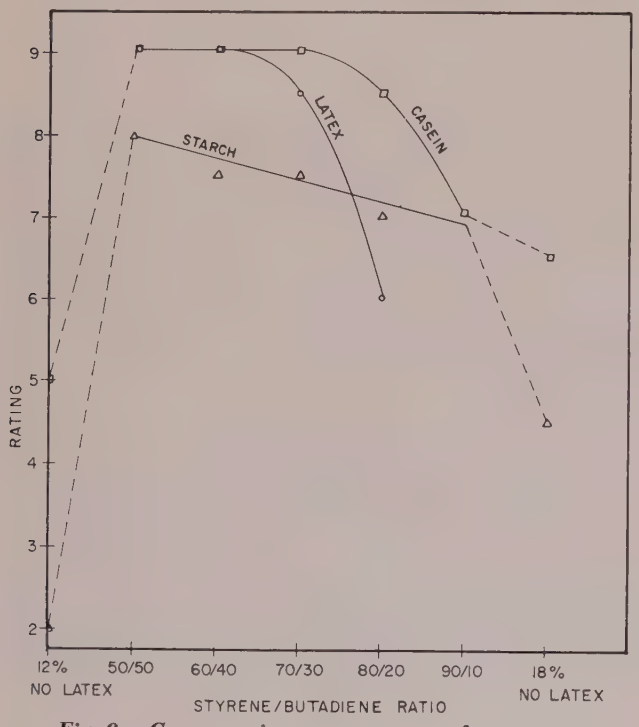

Fig. 9. Crease resistance—average of two tests

resistance to creasing. Again it is noteworthy that the presence of any latex improved the coating in this respect (Table IV).

Stiffness—TAPPI Standard T 451 m-45

The critical length of the coated samples was determined using the Clark softness tester and the stiffness was calculated. All coatings showed a stiffness increase of at least 50% over that of the uncoated raw stock. The natural adhesives, both starch and casein, at the 18% adhesive level produced the greatest stiffness, an increase of 100% over the raw stock. Modifications of these adhesives with any of the copolymers tested produced an increase in the stiffness of 80% over that of the raw stock and showed no significant variation with the varying copolymer ratio.

The coatings based on the all-latex binder system using the 50, 60, and 70% combined styrene content copolymers showed no differences in stiffness and were about 75% higher in stiffness than the raw stock. The coating utilizing the 80/20 styrene-butadiene ratio latex binder was found to be increased by 90% and only slightly lower than the starch and casein combined coatings.

Blocking—TAPPI Standard T 477 m-47

In order to determine whether any of the coatings produced in this series would block under normal conditions of processing, blocking resistance at 44% R.H. was determined using TAPPI Standard T 477. Two changes were made, however. The first was that the test was run up to and including 180°F. The second was in the equipment employed. Instead of glass desiccators, 1 gal. paint cans were used and found to be adequate substitutes. They can be easily sealed after the proper temperature has been obtained and are much less vulnerable to breakage.

None of the coatings showed any degree of blocking at any temperature.

CONCLUSIONS

Styrene-butadiene latices varying in stryene-butadiene ratios from 50/50 to 90/10, when added to starch or casein adhesive systems, were found to modify the properties of clay-coated papers. Flexibility, pigment binding, and varnish ink holdout increased with decreased styrene content. Gloss and smoothness improved with increased styrene content of the copolymer up to 80 parts of styrene. The non-film forming latex, 90 styrene 10 butadiene copolymer, while having no pigment binding properties when used alone, modified starch and casein coating systems to improve wet rub and varnish ink holdout. The degree of improvement with the 90/10 latex was not equal to an equivalent amount of starch or casein. When used as the sole binder, excellent clay coatings were obtained with latices varying in styrene-butadiene ratios from 50/50 to 80/20.

The pigment binding strength of a 50/50 styrene-butadiene latex was found to be superior to equal amount of casein. The 60/40 and 70/30 copolymers were approximately equal to casein and superior to starch, while the 80/20 copolymer latex approximated the pigment binding power of starch. Wet rub resistance appears to reach the maximum with a 70/30 styrene-butadiene copolymer latex.

These investigations largely confirm the work of Taber and Stein (*1*) with the noticeable exception of greater wet rub resistance of the 70/30 styrene-butadiene copolymers.

The results of these studies suggest that maximum benefits could be obtained from the use of stryene-butadiene latices through selection of a specific styrene-butadiene ratio for each type of coating problem, i.e., for gloss and smoothness, an 80/20 and, for maximum pigment binding and flexibility, a 50/50 styrene-butadiene copolymer.

The excellent pigment binding properties of styrene-butadiene latices permits the use of as much latex as cost and rheological requirements of the coating demands.

LITERATURE CITED

1. Taber, D. A. and Stein, R. C., *Tappi* 40, No. 2: 107–117 (February, 1957).

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The Optical Efficiency of Titanium Pigments in Paper Coatings

F. R. MARCHETTI and W. R. WILLETS

It is proposed that the distribution of titanium dioxide pigment in a paper coating is an important factor in determining the optical properties of the coated paper. By analysis of resin films pigmented with various amounts of titanium dioxide, it is established that insufficient spacing between individual pigment particles leads to a loss in efficiency. The particle-to-particle separation at which this loss is first observed is calculated to be about 0.2 to 0.4 μ. The low refractive index extenders used in conjunction with titanium dioxide are shown to exert great influence on the dispersion state of the pigment in the coating. Differences in titanium dioxide efficiency are demonstrated in coatings formulated with coarse and fine clays.

In a previous paper (*1*), the authors discussed the application of pigment volume concepts to certain phases of paper coating technology. It was then proposed that a similar reasoning, that is the consideration of pigment volumes and spatial arrangements, could profitably be applied to the optical properties of paper coatings.

The importance of pigment distribution to optical efficiency has frequently been noted in the past. For example, in a paper describing a procedure for evaluating the opacifying properties of pigments, Adrian (*2*) noted the influence of the packing of pigment particles on the specific scattering coefficient. Willets and Georgevits (*3*) demonstrated the improvements in brightness and opacity of coated paper made possible by milling the coating. More recently Mitton and White (*4*), discussing the effect of pigment dispersion on the tinting strength and hiding power of paints, related degree of dispersion as measured by gloss to the scattering coefficient. Data given for two pigments in four vehicle systems showed the scattering coefficient to increase with the better dispersion demonstrated by increasing 20° gloss readings.

In this report we shall consider the distribution and arrangement of titanium dioxide pigment particles in paper coatings and extend our analysis to describe possible effects on the optical efficiency of the pigment.

THEORETICAL CONSIDERATIONS

The most apparent effect, of course, is that directly dependent upon the relative amounts of air, adhesive, and mineral, including both high and low refractive index pigments. Since the scattering of light passing from one medium into another depends on the difference between the refractive indices, it follows that the relative proportions of air-vehicle, vehicle-mineral, air-mineral interface will greatly influence the optical behavior of the coating film. This effect, most commonly expressed in terms of brightness or opacity versus adhesive ratio by weight, is more accurately depicted as a volume effect.

A second, less commonly considered effect is that due to the spacing between individual pigment particles. Analysis of this effect is complicated by the fact that few, if any, paper coatings are pigmented entirely with titanium dioxide so that the important part played by the low refractive index pigment, usually the major component, must be considered. As for the influence of the adhesive on particle spacing it has been calculated that the PVC (pigment volume concentration) of most paper coatings lies between 70 and 90%, with both low and high refractive index materials considered as making up the pigment content. In an analysis of the effect of extender pigments on the hiding power of titanium dioxide in paint systems, Stieg (*5*) calculated, assuming uniform spherical particles, that closest packing (rhombohedral) occurs at a PVC of 74%, with vehicle solids occupying the remaining 26% of the film. Maintaining the rhombohedral configuration, he then derived the following relationship between PVC and surface-to-surface particle sepration S.

$$S = \sqrt[3]{\frac{0.74}{\text{PVC}}} - 1$$

It may be noted then, that in spite of differences due to deviation from the idealized situation just described, little if any, particle separation is provided by the adhesive content of the average paper coating. This is self-evident when we consider that much of the optical efficiency of paper coatings may be attributed to air-pigment interface, there being insufficient adhesive present to fill the void volume, as noted by Cobb (*6*).

PIGMENTATION OF RESIN FILMS

In turning our attention to the mineral portion of the coating, we find that the titanium dioxide is usually distributed among one or even two low refractive index materials of various particle size and shape. Thus, while it may be comparatively easy to establish the effects on opacity and brightness owing to the various volumes of air, adhesive, and low and high refractive index pigments, such a complex system is not so easily analyzed for effects arising from the distribution of titanium dioxide in the film. In order to develop data on the effects of titanium dioxide particle separation, it was decided to work with the simple system of the pigment in a clear resin matrix. In such a system, the clear resin component would make only a small and fairly constant contribution to the opacity of the pigmented film, even over a substantial range of thicknesses. By preparing films of various pigmentation levels and various thicknesses,

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and measuring contrast ratios, the weight of titanium dioxide per unit area needed to produce a given opacity can be determined at a series of different pigment volume concentrations. In this way, some measure of the optical efficiency of the pigment can be obtained.

The resin chosen was polyvinyl chloride and the pigment was a rutile grade of titanium dioxide. Resin, pigment, plasticizer, and stabilizer were dry blended and then fluxed and mixed for 5 min. on a two-roll rubber mill heated to 330°F. Film thicknesses were controlled by adjusting the clearance between rolls. The pigmented films were prepared at PVC's ranging from about 1.5% to about 16.0%. Unpigmented vinyl films were also prepared, and it was found that the contrast ratio of the clear films was nearly constant, increasing only 1%, from 8.0 to 9.0%, over the 2 to 24 mil thickness range studied. Bausch and Lomb contrast ratios were determined on the variously pigmented films at different thicknesses. From these data the weights of pigment per unit area necessary to produce a contrast ratio of 99% at the various pigment volume concentrations were calculated, this contrast ratio being chosen in order that the PVC levels studied might be extended as high as feasible. It was then possible, making use of the aforementioned relationship between pigment volume concentration and particle separation, to calculate a theoretical distance between particles and gage its effect on pigment efficiency. A plot of the milligrams of titanium dioxide per square centimeter necessary to

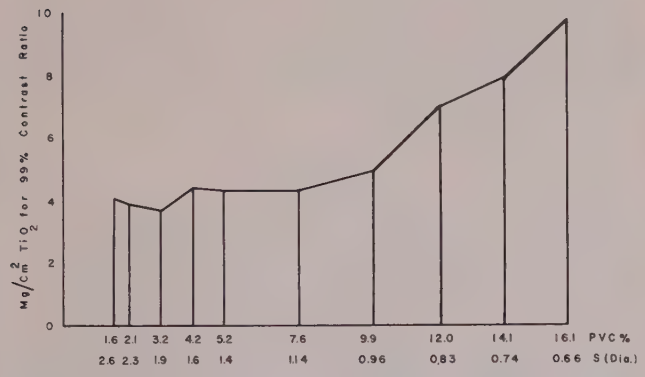

Fig. 1. Effect of particle separation on efficiency of titanium dioxide in polyvinyl chloride film

produce 99% contrast ratio versus pigment volume concentration and corresponding particle separation results in a significant pattern as shown in Fig. 1. Although particle separations were calculated assuming the uniform expansion of a rhombohedron of monodisperse spheres, an admittedly idealized situation, the magnitude of difference in pigment efficiency over a rather narrow range of pigment volume concentration offers some interesting possible interpretations. The pigment volume concentration at which the pigment in the resin film begins to show a loss in efficiency corresponds to a particle separation of about one diameter. This means that the efficiency loss appears to take place at pigment separations less than about 0.2 to 0.4 μ, or about one half the wavelength of visible light. Although this effect will undoubtedly vary in magnitude, depending upon the medium in which the pigment is dispersed, the degree of dispersion, film thickness, level of contrast ratio and other variables, the apparent existence of a concentration point beyond which diminished efficiency occurs is of definite practical interest.

Its significance in paint systems was discussed by Stieg (*5*) in his paper. He pointed out that the hiding power of pigments (expressed in square feet per pound at 98% contrast ratio) increases with decreasing pigment volume up to the point corresponding to a separation of one particle diameter, after which no further increase is observed. The existence of this phenomenon has also been noted in other titanium dioxide pigmented systems, and while the magnitude of the loss may vary in the different instances, efficiency in each case apparently falls off in the range above 9.25% PVC, that is when the separation between particles is less than one diameter.

APPLICATION TO PAPER COATINGS

With such evidence appearing in diverse applications of titanium dioxide pigments, possible influences in paper coatings also seem worth considering. It has been pointed out that the great bulk of paper coating formulations do not contain sufficient adhesive solids to contribute significantly to particle separation. The most

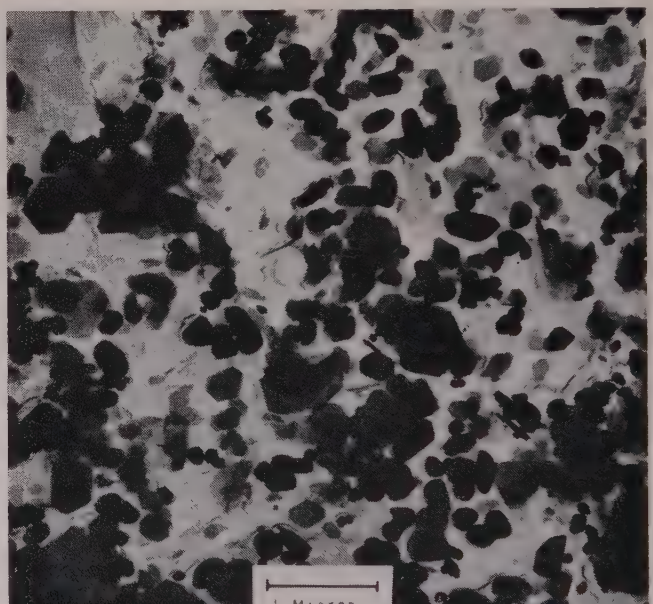

Fig. 2. Replica electronmicrograph of "good" commercial coating showing distribution of rutile pigment (Taken at 33,000 diam.)

important factor controlling the distribution of a properly dispersed titanium dioxide pigment in a paper coating is, therefore, the low refractive index extender. To provide optimum spacing and separation, the extender material should be of uniform, fine particle size, though not substantially finer than 0.3 μ, the average particle size of titanium dioxide pigments. Coarse, polydisperse substances tend to form large irregular voids which trap and flocculate the titanium dioxide particles, with a resultant loss of scattering power and, consequently, pigment efficiency.

Both clay and calcium carbonate, the two low refrac-

tive index pigments most commonly used in conjunction with titanium dioxide, are found in a rather wide range of particle sizes. In coating formulations which include titanium dioxide there may be a tendency to use less refined grades of these materials in the interest of keeping raw material costs down. Actually the use of coarser, less uniform grades is reflected, not only in the lessened contribution by the extender to the optical properties of the coating but also in an adverse effect on the efficiency of the titanium dioxide.

Such theoretical considerations are certainly of fundamental interest in evaluating coatings even though actual interpretation of electronmicrographs may not substantiate them exactly.

For example electronmicrographs were taken of two small samples of commercially coated paper of which one was reported to be "good" (Fig. 2) and the other

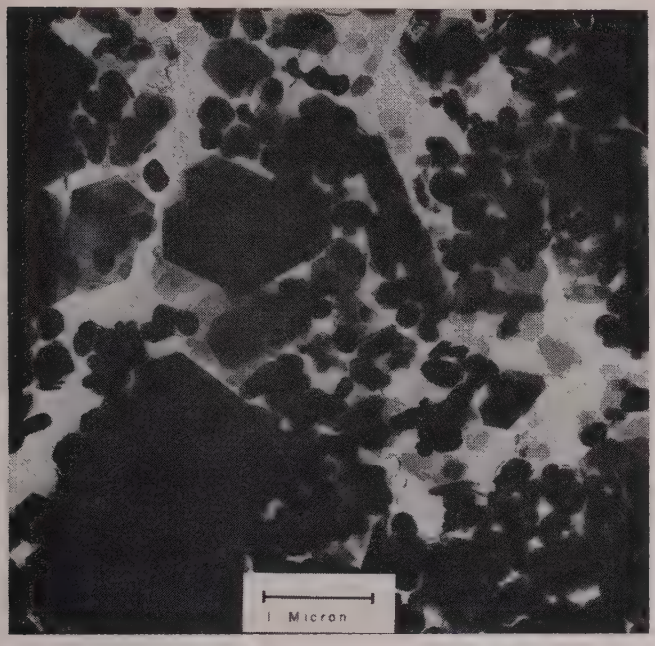

Fig. 3. Replica electronmicrograph of "bad" commercial coating showing distribution of rutile pigment (Taken at 33,000 diam.)

"bad" (Fig. 3). Each coating contained titanium dioxide and clay. These electronmicrographs were taken at high magnification (33,000×) using the direct carbon-replica technique. The electronmicrographs are revealing because not only are the components of the coating clearly discernible but differences are indicated between the samples. The clay particles are characterized as thin platelets of low electron opacity while the titanium dioxide particles are more or less equiaxed and of high electron opacity. It appears that the clay in the "bad" sample is coarser and more clumped than the clay in the "good" sample, and therefore separates the titanium dioxide to a lesser degree. The titanium dioxide particles are moderately well distributed in both, except in certain areas of the "bad" sample containing large clay particles. These figures serve to show a definite difference in spatial relationships even though they do not follow the ideal fundamentals suggested by theoretical considerations.

The examination of these two samples of commerical paper (too small, however, to permit optical tests and which were submitted as merely "good" and "bad") led to further work on samples whose history was known and for which data could be obtained. In this case a dispersion of rutile titanium dioxide pigment was prepared and mixed with a slurry of fine clay (average particle size about 1 μ) and also with a slurry of coarse clay (average particle size about 4 μ). Starch was used as the adhesive. Coatings weighing 10 lb. per ream were applied to two regular raw stocks, the sheets lightly calendered and tested. The results are given in Table I. Electronmicrographs were taken as described above using carbon-replica technique for the lighter weight coated raw stock.

The mixture of titanium dioxide and fine clay gave superior opacity and the brightness both before and after waxing. The gloss was also higher for the combination made with the finer clay. Such differences can be explained on the basis of the electronmicrographs (taken at a magnification of 8000×), where Fig. 4 represents the coating made with the fine clay-titanium dioxide combination and Fig. 5 the one made with the coarse clay-titanium dioxide combination. These show differences in the relative degree of flocculation and distribution of the titanium dioxide particles. In Fig. 4 with the fine clay the titanium dioxide is distributed as open structure flocculates while in Fig. 5, with the coarse clay, the titanium dioxide appears as denser flocculates with indication of pigment packing around the coarse clay particles. There seems to be some difference between the distribution in the commerical and experimental samples. This might be explained on the basis that the coating of the experimental samples was fairly heavy, and furthermore it was air-dried which would tend to give any flocculating effects during drying more time to take place.

Even though such electronmicrographs do not exactly

Table I. Effect of Fine and Coarse Clays on Coatings Containing Rutile Titanium Dioxide Pigment

	Rutile and fine clay	*Rutile and coarse clay*
48.5 lb. (25 × 40—500) Raw Stock		
% Opacity		
Unwaxed	91.0	89.0
Waxed	72.5	67.0
% Brightness		
Unwaxed	78.2	76.0
Waxed	62.0	60.5
% Gloss—75°	43	27
140 lb. (25 × 40—500) Raw Stock		
% Opacity		
Unwaxed	98.5	98.0
Waxed	84.0	80.5
% Brightness		
Unwaxed	80.5	79.0
Waxed	67.0	66.0
% Gloss—75°	37	17

Pigmentation: Rutile titanium dioxide 18.4% by weight, 12.2% by volume; clay 81.6% by weight, 88.8% by volume; starch adhesive ratio 18.5% by weight, 74% PVC; coatings applied at 10 lb/per ream; all samples calendered one nip.

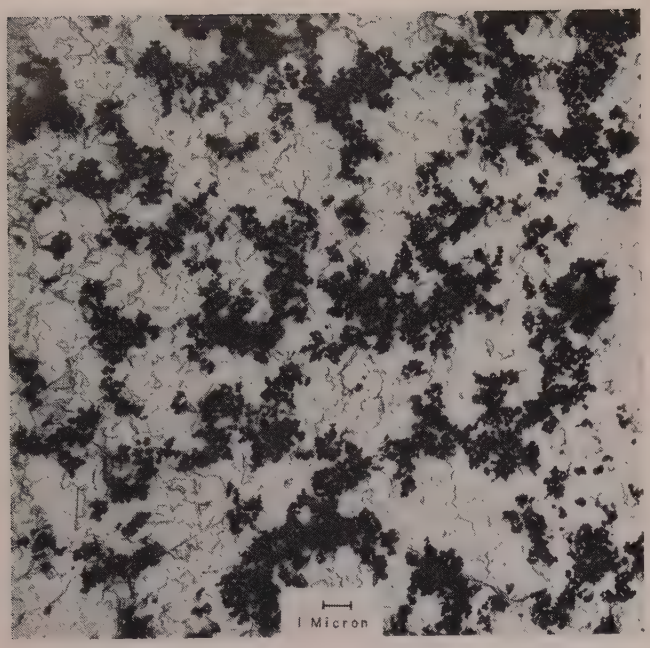

Fig. 4. Replica electronmicrograph showing distribution of rutile pigment in coating with fine clay (Taken at 8000 diam.)

illustrate the diagrams of theoretical spatial relationships they at least serve to demonstrate that such spatial relationships exist and vary with different combinations.

It should be pointed out that the differences which existed in the optical properties of the experimental coated sheets were greater in magnitude than those which could be attributed only to the fine and coarse clays used as extenders. Samples coated only with such fine and coarse clays showed some differences but these were much less than when the rutile-pigmented coatings were used. Waxing accentuated the differences in the rutile pigmented sheets but had little effect on differences between sheets coated only with the fine and the coarse clay. It is logical to conclude that in addition to the effects attributable to a fine or coarse clay, per se, there is also an added effect in determining the particle separation of the titanium dioxide pigment, which separation is an important factor in governing the pigment's efficiency.

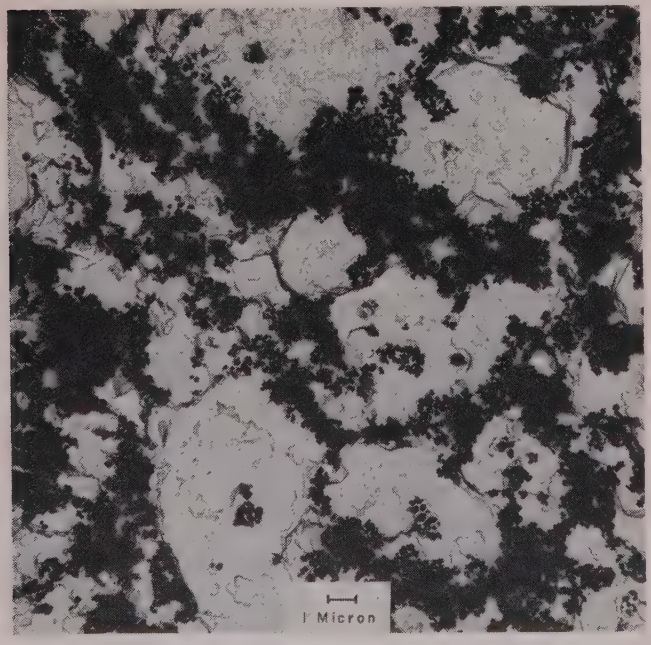

Fig. 5. Replica electronmicrograph showing distribution of rutile pigment in coating with coarse clay (Taken at 8000 diam.)

CONCLUSION

The two factors which influence titanium dioxide pigment distribution in a paper coating are, first of all, the degree of dispersion achieved during coating preparation and, secondly, the safeguarding of this dispersion by the use of a fine, uniform particle size extender. The importance of maintaining proper particle separation has been demonstrated and a loss in pigment efficiency is seen to take place where insufficient separation exists. By theoretical treatment, the point at which pigment efficiency begins to drop off has been established as 9.25% PVC, corresponding to about one particle diameter or one half the wavelength of visible light, that is 0.2 to 0.4 μ. Though electronmicrographs of coated paper surfaces reveal quite a variance from the idealized theoretical treatment, experiments with coatings containing titanium dioxide, formulated with coarse and fine clays, indicate a decided practical importance for the particle spacing effect.

At the high PVC concentrations of most paper coatings, maintenance of the optimum titanium dioxide particle spacing is one of the important functions of the low refractive index pigment. Even in instances where the pigment volume concentration may be drastically lowered by subsequent treatment such as waxing, varnishing, impregnating or printing, the influence of particle separation will persist. In such cases, for optical purposes, the extender pigments may be considered almost as part of the total vehicle solids, because of the small different in refractive index between these pigments and the various media.

To sum up, while the actual physical state of titanium dioxide pigment in a system as complex as a paper coating may not conform exactly to the configurations upon which theoretical considerations are based, the principles which emerge are valid and may be profitably applied by the paper coatings technician.

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The Effect of Pigment Combination and Solids Concentration on Particle Packing and Coated Paper Characteristics

I. Relationship of Particle Shape to Particle Packing

R. W. HAGEMEYER

A study was made to determine the effect of particle shape on particle packing. Three basic shapes were investigated ... the plate, the needle, and the rhomb. Packing was determined by various methods and under various conditions. In the systems investigated, it was observed that the dry mixtures, water dispersions, and plastic models had different packing tendencies. The dry mixtures had increased packing as the percentage of plates was increased, while the plastic models had decreased packing as the percentage of plates was increased. For the water dispersion, initially, packing decreased as either the needles or rhombs were added to the plate particles. This was indicated by the increase in the volume occupied by the pigment particles. In each water system, the composition which exhibited maximum volume contained 80% plate particles. The curves for the two mixtures ... needles-plates and rhombs-plates ... are similar in shape for all methods of test. While there was a difference in the actual values obtained for the two mixtures, the significance of the difference has not been determined. The conclusions reached were that (1) the shape of the pigment particle does influence its packing; (2) the effect of shape varies widely depending upon the system investigated; (3) for water systems, dilution, when accompanied by flocculation, results in decreased packing independent of particle shape; (4) water drainage rate is probably influenced by particle shape but the relationship is not a simple one; (5) particle packing does influence the flow properties of pigment slips.

By way of introduction to the initial reports on TAPPI Project 600, it would be well to define the area to be covered in this work. Possibly the easiest way to visualize the scope of this project is to break up the title, "The Effect of Pigment Combinations and Solids Concentration on Particle Packing and Coated Paper Characteristics," into its constituent parts. By doing this it becomes apparent that there are four major areas to be studied, namely, (1) the effect of pigment combinations on particle packing, (2) the effect of pigment combination on coated paper characteristics, (3) the effect of solids concentration on particle packing, and (4) the effect of solids concentration on coated paper characteristics. Also, there are two sub-areas which could be added, namely, the effect of pigment combination on solids concentration and the effect of particle packing on coated paper characteristics.

In a system comprised of four major, two minor, and a whole host of secondary or inherent variables, it is necessary to make rather broad basic assumptions. In this work all variables were ignored except the one being investigated. Following this assumption, the initial reports on Project 600 deal with the effect of pigment combinations on particle packing with particle shape as the variable. The report that follows covers work done during 1957, 1958, and 1959 for Progress Report No. 1 (*4*) and Progress Report No. 2 (*5*) which were circulated in the Coating Committee but not published.

The term "particle packing" refers to the manner in which a particle arranges itself in relation to another particle. It pertains to the proximity of one particle to another, both from the standpoint of distance and geometric configuration. Packing or stacking can be orderly though generally it is a random arrangement of particles. Packing is usually expressed as tight or loose depending upon the closeness of approach of the pigment particles.

While the term "particle packing" seems simple enough, the phenomenon it describes is extremely complex. There are a number of theories offered to explain particle orientation and arrangement; but unfortunately, the evidence to support the theories is quite limited in some cases and completely lacking in others. It is the objective of this work to study particle packing from the standpoint of the factors which influence it, and also to determine the importance of particle packing on the final, coated paper properties.

Some idea of the complexity of the packing phenomenon might be gained from the fact that there is no known system of calculating from measurable values, such as particle size, particle shape, and the like, just what the packing of any particular collection of particles will be. The problem has been studied intensively by various scientists in many industries. For example, Furnas (*1*) did considerable work on coals while Groton and Fraser (*2*, *3*) ran studies on actual and simulated, naturally occurring sediments. The conclusions drawn from the work of these and other authors are that packing cannot be predicted.

There is one notable exception to this rule—this being the case for spheres of uniform diameter. In this instance, packing has been thoroughly described and mathematical formulas are available. However, even in the case of spheres, mixing the particle size quickly introduces a degree of complexity not solvable theoretically. Since none of the paper coating pigments have particles consisting of spheres of uniform diameter, it follows that there is no known means of calculating particle packing from specific values for

R. W. Hagemeyer, Wyandotte Chemical Co., Wyandotte, Mich. Project 600 sponsored by the TAPPI Coating Committee.

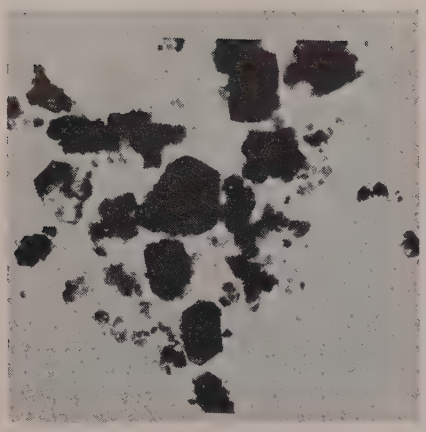

Fig. 1. Domestic clay

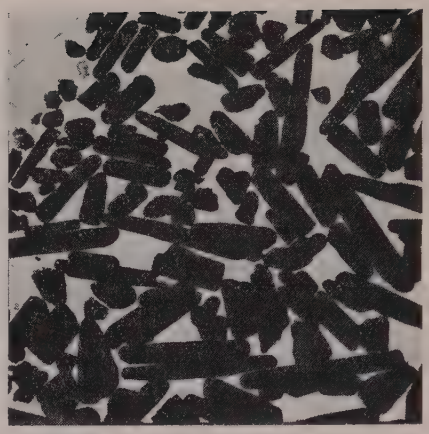

Fig. 2. Acicular carbonate

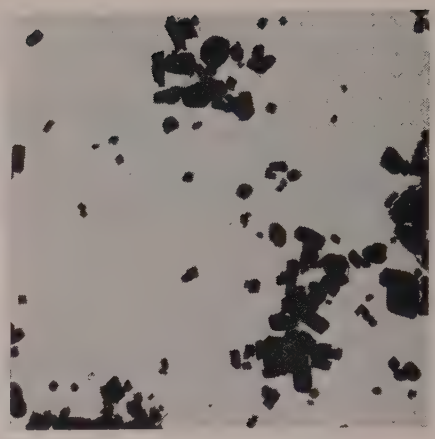

Fig. 3. Rhombic carbonate

Reference bar (lower right corner), 1 μ

coating pigments. In view of this, it was decided to investigate some of the factors which could influence particle orientation and packing in the hope that general trends might be found.

It has long been felt that the two primary factors which govern the particle packing tendencies of paper coating pigments are particle size and particle shape. The influence of secondary factors, such as specific gravity, surface activity, particle attraction, etc., has been considered minor by comparison. Operating under this premise, it was decided to investigate the influence of particle shape on packing, while holding particle size constant. The effect of other variables such as particle size, size range, and size distribution on packing may be studied later.

Since kaolin clay is the most widely used paper coating pigment, it is only natural that its hexagonal plate form should be one of the shapes investigated. Precipitated calcium carbonate is second in volume used; therefore, its rhombic and acicular, or needle-shaped, particles were added to the shapes to be studied. While there are substantial quantities of other pigments used in paper coatings, their particle shapes were not felt to be sufficiently different to include them in this work.

For instance, the rhomb-shaped calcium carbonate particle closely resembles the shape of the titanium dioxide particle, while zinc oxide would be similar in shape to the acicular or needle-shaped calcium carbonate particle. Also the hexagonal, clay plate is not too dissimilar from the flat, circular plate which characterizes diatomaceous silica. Further, the above products all have approximately the same specific gravity and refractive index, thus eliminatng two variables from the work. This investigation then deals with the particle packing tendencies of the hexagonal plate, the rod or needle, and the rhomb. The three products used in this work are all commercial pigments which are being used currently for paper coating.

Since the tendency of clay mineral to exist in the form of individual, hexagonal plates, rather than stacks of plates, increases as particle size decreases, it was decided to use a fine rather than a coarse particle clay. The specific clay used is reported by the manufacturer to have 90% of the particles finer than 2 μ, as measured by the centrifugal sedimentation method.

The clay (Fig. 1) was examined under the electron microscope and found to be composed of individual platelets or stacks made up of approximately three to five plates. While there undoubtedly are some larger stacks present in this product, they were not ellident in the small samples subjected to microscopic examination.

The acicular, precipitated calcium carbonate (Fig. 2) has particles ranging from 0.5 to 1.5 μ in length and from 0.1 to 0.3 in thickness. There were only a few particle clusters in the sample examined, and the aggregates that did exist appeared to be loosely held.

The rhombic, precipitated calcium carbonate (Fig. 3) used in this work is reported to have a particle size of from 0.1 to 0.2 μ. Further, from 3 to 5% of the total particles are present in the form of aggregates which may be as large as 1 μ in size.

Since clay is almost always one of the pigments used in paper coating color, it was felt that the combinations to be studied should consist of clay and either the acicular, or rhomb-shaped calcium carbonate. The initial work dealt with evaluating the particle packing

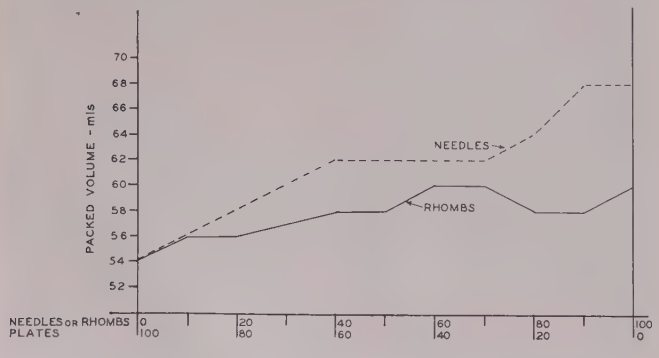

Fig. 4. Packed volume—dry pigment mix

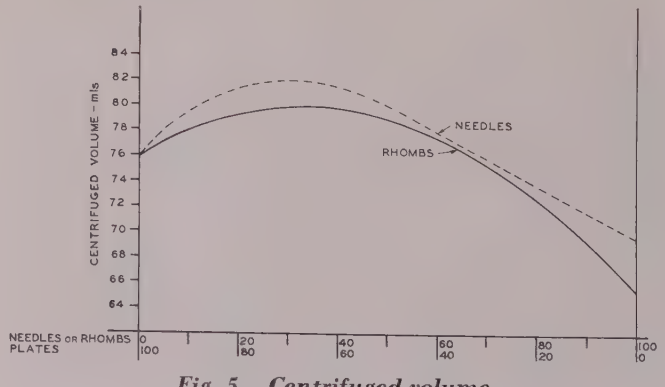

Fig. 5. Centrifuged volume
50% dispersed solid—centrifuged 1 hr.

Fig. 6 (top view). 100% plates

Fig. 7 (top view). 90 plates/10 needles

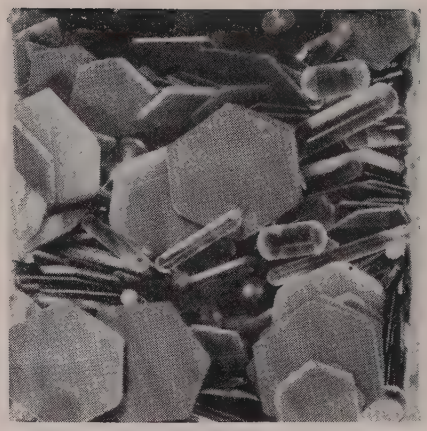

Fig. 8 (top view). 70 plates/30 needles

tendencies of the clay plate with either the needle or rhomb-shaped calcium carbonate particle over the entire range from 100% plates to 100% needles or rhombs. Combinations of the rhombs and needles were not investigated. The data indicate the particle packing tendencies of these particles as determined by four different methods:

1. Packed volume of dry pigment blends.
2. Centrifuged volume of aqueous dispersed blends.
3. Visual observation of the magnified particles.
4. Packed volume of the magnified particles.

It should be noted that this represents three basically different approaches to the study of particle packing. First, packing was studied for the dry powders with air as the suspending medium. In view of the almost infinitesimal mass of the individual particles, the effect of the suspending medium, in this case air, is significant. Second, packing was detemined by working with aqueous dispersions of the three products. It is felt that this somewhat approaches the actual conditions present in paper coating work. Third, packing was determined for plastic replicas of the three materials. In the third case, practically all exterior forces can be ignored, including the effect of the suspending medium.

In going over the data, it should be remembered that they present a very simple system and may or may not apply in a specific coating color. The variables of coating solids, method of application, viscosity of suspending media, action of adhesives, action of coating base stock, etc., have not been considered in this particular phase of the investigation. Also, in going over the graphs, attention should be focused on the trends indicated. The numerical values used in the plots are of minor importance.

1. PACKED VOLUME OF DRY PIGMENT BLENDS

The various blends of the dry pigments were prepared by dry tumbling with glass beads to ensure homogeneous mixing. The glass beads were removed by screening, then 40 g. of each blend were weighed out and transferred to a 250-ml. graduated cylinder by means of a smooth, paper chute.

The graduated cylinder was stoppered and placed in a motor driven mechanical, dropping machine. The machine is so constructed that lifting, rotating, and dropping of the cylinder is accomplished by means of a special cam rotating at the desired speed of 30 drops per min. After the machine had packed the sample for an interval of 10 min., it was stopped; and the volume of packed, dry pigment mix was read. The machine was restarted, and the packing continued until a constant volume reading was obtained.

The first graph (Fig. 4) shows the data obtained when pigments having the three basic shapes—the plate, the needle, and the rhomb—are blended together in dry form. The results indicate that minimum volume or maximum packing was obtained for the plates. As the other particle shapes are introduced, packing decreases as is indicated by the increase in volume. Maximum volume or minimum packing was obtained for the needles, with slightly less volume and more packing for the rhombs.

Fig. 9 (top view). 50 plates/50 needles

Fig. 10 (top view). 30 plates/60 needles

Fig. 11 (top view). 10 plates/90 needles

Fig. 12 (top view). 100 needles

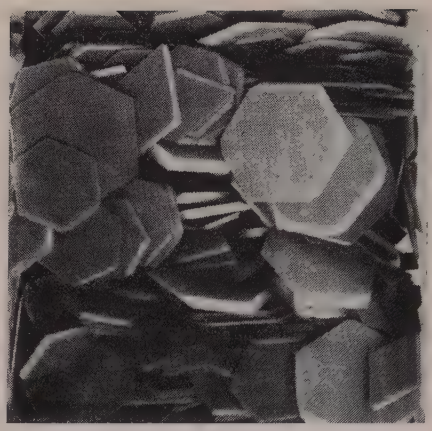

Fig. 13 (top view). 90 plates/10 rhombs

Fig. 14 (top view). 70 plates/30 rhombs

2. CENTRIFUGED VOLUME OF AQUEOUS DISPERSED BLENDS

The pigment blends were dispersed at 70% solids in plain water and then diluted to 50% solids. Following this, 210 g. of the 50% solids, aqueous dispersion were added to a round bottom, cylindrical, centrifuge bottle of known volume (approximately 235 cc.). The aqueous dispersions of the pigment blends were then centrifuged at 2,000 r.p.m until the supernatant liquid above the centrifuged solids was clear. The clear liquid was carefully decanted. Then, a measured volume of water was added to the solids in the centrifuge bottle bringing the total volume up to the measured volume of the bottle. The volume of the solids was then calculated. Incidentally, no dispersants were used in this work in an attempt to keep the systems as simple as possible.

It can be seen (Fig. 5) that the two curves are much closer together and are of similar shape. Initially, the addition of the needles or rhombs to the plates produces an increase in volume or decrease in packing. The curves reach a maximum volume of minimum packing point at approximately a 30–70 mixture and then decrease in volume beyond this point. Maximum volume is obtained with the needles with slightly less volume or more packing for the rhombs.

Up to this point the data presented were obtained by working with the actual pigment particles. In an attempt to eliminate variables that might be attributed to the microscopic size of the real particles, it was decided to make up working models of the three products. In this way, the particles could be readily handled and also, visually observed without the aid of instruments.

3. VISUAL OBSERVATION OF THE MAGNIFIED MODELS

At the time the three products under study were examined under the electron microscope, five photos were taken of each product. The photomicrographs were projected on a large screen and particle size counts made to determine both size and size distribution. These data were used as the basis for making the working models. While the actual samples had an endless number of different sized particles present, in making the models, it was necessary to take a few representative particles and reproduce them in various proportions to simulate the actual curves. In each case there were practically no aggregates present so they were ignored in making up the models.

The models represent 50,000 magnification replicas of the three products. The hexagonal clay plates were made of yellow plastic, the acicular calcium carbonate of clear plastic, and the rhombic calcium carbonate of dark red plastic. The same plastic was used in all cases, the one difference being in color.

The models were blended in various proportions, poured into a Plexiglas box, and visually examined. Following this, the box was given a 2-in. drop ten times, and another visual examination was made. Also, before and after photographs were taken to provide a

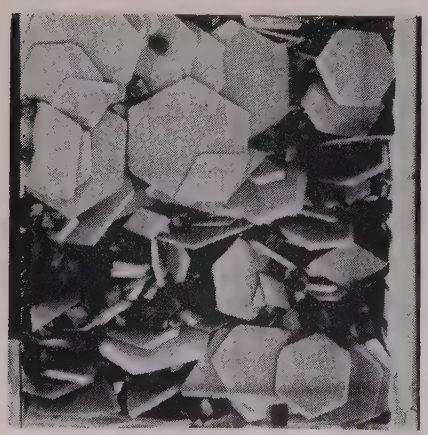

Fig. 15 (top view). 50 plates/50 rhombs

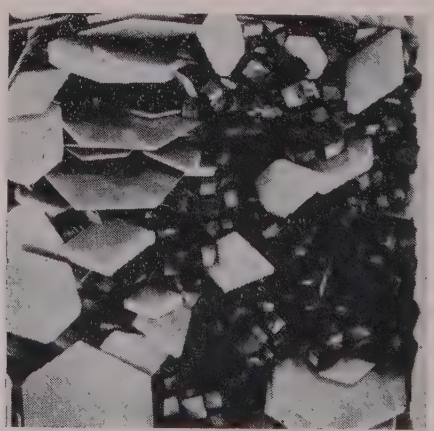

Fig. 16 (top view). 30 plates/70 rhombs

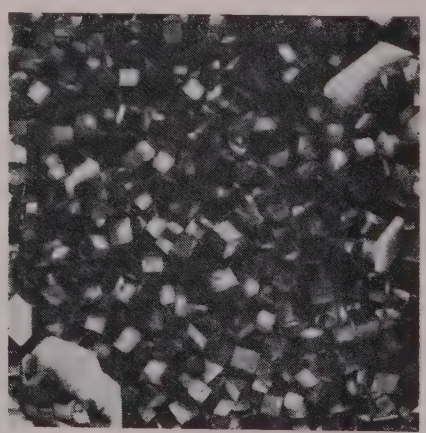

Fig. 17 (top view). 10 plates/90 rhombs

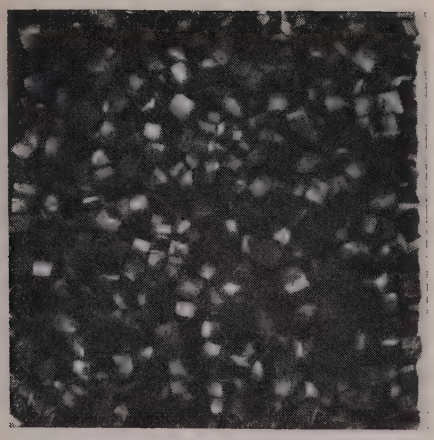

Fig. 18 (top view). 100 rhombs

Fig. 19 (side view). Packed—100 plates

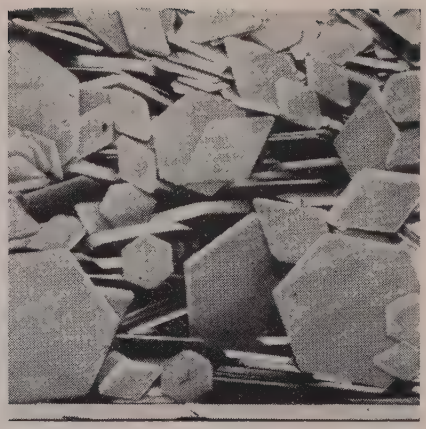

Fig. 20 (side view). Packed—90 plates/10 needles

permanent record of what was observed. The results of this work are summarized in pictures illustrating top view (Figs. 6–18) and side views (Figs. 19–31) after packing for the various blends.

In observing the models, it was interesting to note that individual, discrete particles under the influence of no exterior force except gravity, tended to group together in aggregates or stacks. Further, once the groupings were formed, no force less than complete remixing would break the clusters. In fact, most of what might seem to be orienting forces, such as shaking in a horizontal plane, tended to increase the aggregation.

4. PACKED VOLUME OF MAGNIFIED PARTICLES

The working models were blended together in various proportions to study the packing tendencies of the plate-needle and the plate-rhomb systems. The blends were thoroughly mixed by hand so as to effect a representative uniform mixture. A weighed portion of each blend was carefully added to the Plexiglas box (9 by 12 by 6 in.) and the height of the pigment models noted. The box was dropped 10 times from a height of 2 in. This represented the packing effort. The height of the pigment models was noted, and the packed volume was calculated.

Data for this study are shown in Fig. 32. Here we note a gradual decrease in volume or increase in packing as the percentage of platelike particles is decreased.

In view of the difference observed in packing, it can be seen that the conditions under which packing takes place are very important. By varying the conditions, the trends can be completely reversed, as happened in cases 1 and 3, while the results for case 2 were intermediate. Since the water dispersions used in case 2 most closely approach conditions experienced in paper coating colors, it was decided that a more thorough investigation should be carried out in this area to see what information could be developed.

Packing, which refers to the closeness of approach of the pigment particles, can be expressed in terms of apparent density of the packed pigment, or in terms of the inverse of density, specific volume. In this work, following the example of certain works published earlier, and to correlate with it, the volume measurement was used. In the remainder of this work, the data are expressed in terms of relative volume rather then specific volume. By doing this, the volume figure is independent of density.

At this point it might be well to explain the term relative sediment volume and also to point out how it differs from specific volume. Specific volume is the volume actually occupied by an amount of packed solid containing a unit weight of solid. The total volume occupied by the unit weight will vary with the density. Relative sediment volume, on the other hand, is based on a unit volume rather than unit weight basis, and therefore is independent of density. The relative sediment volume concept is illustrated in Fig. 33.

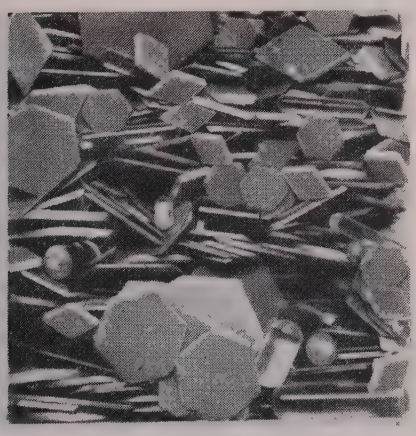

Fig. 21 (side view). Packed—70 plates/30 needles

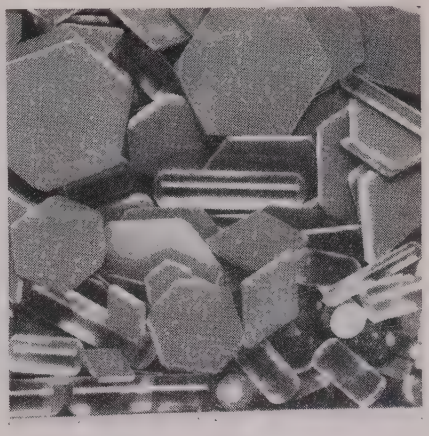

Fig. 22 (side view). Packed—50 plates/50 needles

Fig. 23 (side view). Packed—30 plates/70 needles

Fig. 24 (side view). Packed—10 plates/90 needles

Fig. 25 (side view). Packed—100% needles

Fig. 26 (side view). Packed—90 plates/10 rhombs

It can be seen that relative sediment volume is made up of the combination of solid volume and void volume. In practice this combination occurs as shown in Fig. 34. The solid volume is made up of the actual pigment particles, while the void volume is compose of the space between the particles. Relative sediment volume combines the two and is representative of what actually occurs.

The pigment slips were carefully prepared with every effort being made to insure complete dispersion and deflocculation. This was done to eliminate, as much as possible, the presence of particles in clusters, and thereby permit the effect of particle shape and proportion of shapes in the mixtures to be more clearly evaluated. The procedure used to accomplish this involved high density mixing at 75% solids in the presence of the optimum quantity of dispersing agent for the particular pigment involved. The optimum quantity of dispersant was determined by making mixes at various dispersant levels and then plotting viscosity versus dispersant concentration.

It should be noted that different dispersants were used in each case. The dispersants selected were felt to be the best products available for the particular pigments in question. While it is true that using different dispersants introduces another variable into the study, it was felt that the advantage gained by using the most efficient dispersant for each product more than offset this shortcoming.

The results of this work are shown in Fig. 35, 36, and 37. The graphs show that the optimum quantity of dispersing agent is different for each of the three materials—the values being 0.3% for the plates (Fig. 35), 1.0% for the needles (Fig. 36), and 1.0% for the rhombs (Fig. 37).

The pigments were dispersed individually at 75% solids and then diluted to 70% solids before being blended in various proportions. Then, the blends were further reduced to the various solid levels studied. The principal pigments slips used in the work are shown in Table I.

Each one of these 11 pigment slips was studied at five different concentrations: 70, 65, 60, 55, and 35% solids. This amounts to a total of 55 basic determinations in each series and, further, all tests were run in duplicate. In view of the large number of determinations, the mass trends observed should be representative of the packing characteristics of these particular materials and combinations.

Table I. Shape Blends

	1	*2*	*3*	*4*	*5*	*6*
Rhombs	...	20	40	60	80	100
Plates	100	80	60	40	20	0
	7	*8*	*9*	*10*	*11*	
Needles	...	20	40	60	80	100
Plates	100	80	60	40	20	0

The actual determinations were as follows:

1. Relative sediment volume was determined by centrifuging the pigment slips.

Fig. 27 (side view). Packed—70 plates/30 rhombs

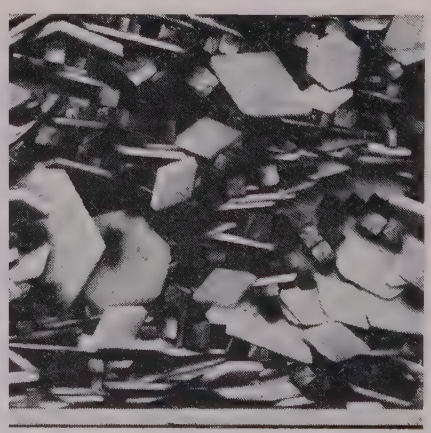

Fig. 28 (side view). Packed—50 plates/50 rhombs

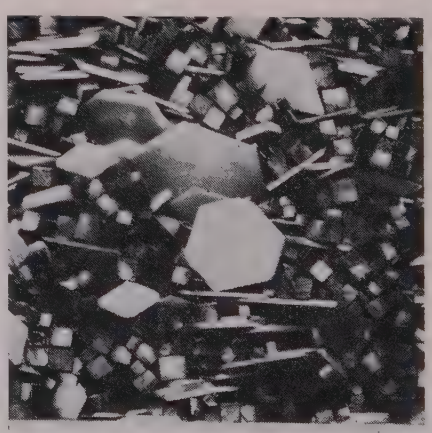

Fig. 29 (side view). Packed—30 plates/70 rhombs

Fig. 30 (side view). Packed—10 plates/90 rhombs

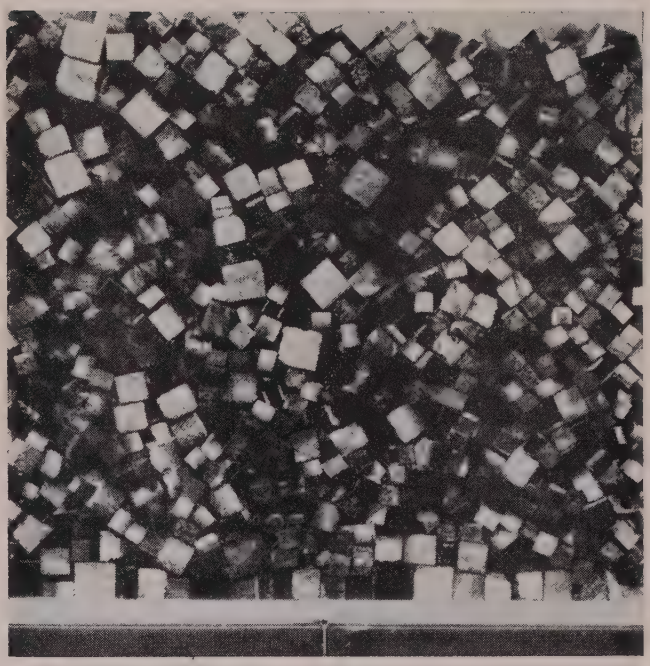

Fig. 31 (side view). Packed—100% rhombs

2. Filter cake solids was determined by pressure filtration of the pigment slips.

3. Brookfield viscosity of the pigment slips was determined.

4. Hercules viscosity of the pigment slips was determined.

5. Drainage rate was determined by pressure filtration of the pigment slips.

1. RELATIVE SEDIMENT VOLUME BY CENTRIFUGING

Samples of the various pigment slips were centrifuged at 2800 r.p.m. for 90 min. The volume of the final solids was determined and, from this, relative sediment volume was calculated. The plot of relative sediment volume versus shape blends for the needle-plate mixtures is shown in the next graph (Fig. 38). While this determination was made at all five solids levels—70, 65, 60, 55, and 35% solids—only the values for 70, 60, and 35% are shown. The 65 and 55% solids curves are similar in shape and fall proportionately between the 70 and 35% solids curves.

It can be seen that for any one curve the relative sediment volume increases rapidly, reaching a maximum when 20% needles have been introduced. To further define this portion of the curve, spot checks were fun on 10–90 mixtures. The curve shown was drawn with these data included. As the proportion of needles is increased beyond the 20% value, the relative sediment volume decreases quite rapidly at first, and then gradually to the 100% needle coordinate.

The other point worthy of note is the effect of dilution and the accompanying flocculation on the relative sediment volume. Naturally, the particles held together in large clusters cannot pack as tightly as the individual particles, so volume increases. Further, as the number of clusters increased in proportion to dilution, relative sediment volume correspondingly increased. This can be seen from the graph with the 60% solids volume being more than the 70% solids volume; and the 35% solids volume . . . still greater. Also, it should be remembered that increased volume represents decreased packing.

The next graph (Fig. 39) shows similar data for the rhomb-plate shape blends. Here again, only three of the five curves are shown. All the curves are similar in shape and spaced in proportion to the per cent solids of the original pigment slip. An even more interesting fact is that these curves very closely resemble those obtained for the needle-plate shape blends shown in the

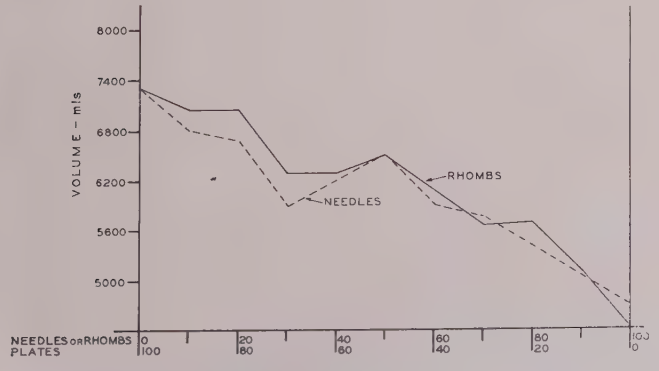

Fig. 32. Volume relationship of magnified particles

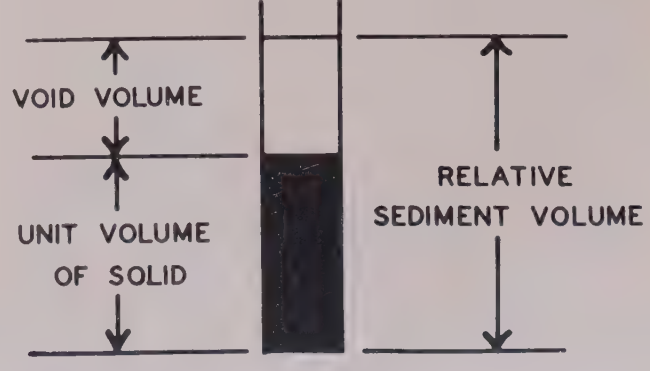

Fig. 33

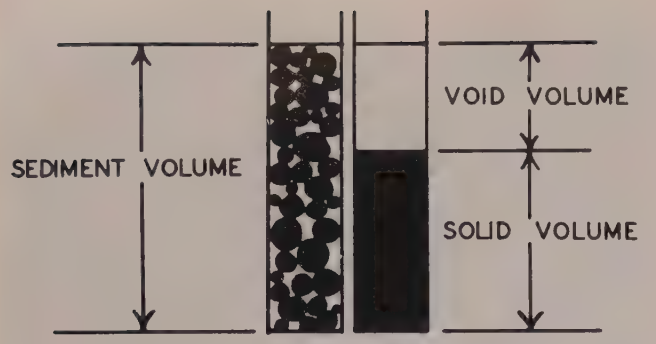

Fig. 34

previous graph. While the maximum point is not quite so pronounced, and the actual relative sediment volume values are slightly lower, the general profile is the same. The significance of the difference in the actual values has not been determined as yet. In any event, the similarity of the two sets of curves was not anticipated, especially in view of the radical differences in the shape combinations used. This illustrates the point that particle packing of nonspherical shapes cannot be predicted.

Any further interpretation of the data would be premature until the significance of the relative sediment volume values is clearly defined in terms of performance properties. Some of the data on viscosity which will be presented later in this report would seem to indicate that these differences in relative sediment volume are important, at least so far as flow properties are concerned.

2. FILTER CAKE SOLIDS BY PRESSURE FILTRATION

Samples of the various pigment slips were filtered using Baroid pressure filtration cups and 100 p.s.i. nitrogen pressure. The results for the needle-plate shape blends are shown in the next graph (Fig. 40). While the data are expressed in terms of per cent solids for the filter cake, the curve shown very closely resembles that for the relative sediment volumes by centrifuging. However, there is one fundamental difference; in this case, dilution of the pigment slips did not affect the result. The final solids were the same regardless of dilution. The curve shown in representative of all five dilutions—70, 65, 60, 55, and 35%.

It is felt that the capillary forces exerted by the water leaving the cake were of sufficient magnitude to break down the flocs formed by dilution, thus eliminating differences in packing due to flocculation. The relative sediment volume for the 35% solids slips as determined by centrifuging was recalculated in terms of per cent filter cake solids, and is presented to show what the curves would have been if flocs were present. Both curves are similar in shape. If the relative sediment volume determined by centrifuging the 70% solids slips is treated in the same manner, the resulting curve is nearly identical to that shown for the actual pressure filtration. Putting it another way, the 70% curves are practically the same and seem to be independent of the method used for the determination.

These data also provide another interesting fact—if the theory on flocculation break down is correct, then it is reasonable to assume that the 70% solids pigment slips are completely deflocculated. Otherwise, the 70% solids values by centrifuging would not have agreed with the filtration data. It is important here to differentiate between flocs which are clusters of particles held together by secondary forces in a chemically reversible manner and aggregates which are clusters of particles cemented together usually in drying, and which once broken do not reform under ordinary circumstances.

The data for the rhomb-plate shape blends are shown in the next graph (Fig. 41). Here again, the initial solids level of the pigment slip did not affect the final filter cake solids; or in other words, flocculation is not a factor. The curve closely resembles that shown for relative sediment volume by centrifuging, but is independent of initial solids. The curve obtained by recalculating the 35% solids data, determined by centrifuging, is shown for comparison purposes.

The results seem to indicate that determination of particle packing by pressure filtration is a more suitable method than determination by centrifuging for, in the filtration procedure, flocculation can be ignored. This observation will have to be verified by checking flocs of various densities and in a variety of suspending media. There may be cases where the tightness of the floc is such that the capillary forces exerted by the receding liquid will not be sufficient to break up the clusters. This could come about in one of three ways: by increased strength of the floc, by decreased surface tension of the suspending medium, or by a combination of the two.

3. BROOKFIELD VISCOSITY

The viscosity of the various pigment slips was checked with the Brookfield viscometer. As would be expected, the actual viscosity was proportional to the per cent solids of the slip and reflected differences in dilution. However, the purpose of this determination

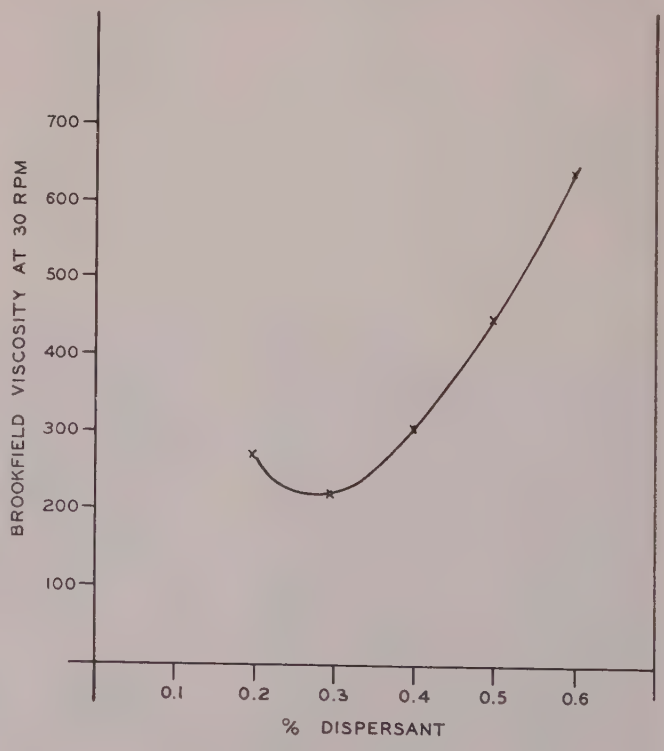

Fig. 35. Brookfield viscosity at 30 r.p.m. versus per cent dispersant

Plates—70% solids—Calgon.

was to demonstrate the relationship between relative sediment volume and viscosity or flow properties. Therefore, viscosities at constant solids levels should be compared. The experimental data illustrate this fact, with changes in viscosity at a constant solids level being directly proportional to changes in relative sediment volume for the individual pigment slips. The values obtained at 65% solids for the needle-plate shape blends are shown in Fig. 42. The curve closely resembles that obtained both by centrifuging and pressure filtration. The viscosities at this particular solids level are presented because they show on a direct plot the similarity of the curves. Viscosities at other levels while proportional would have had to be plotted on a different scale to bring out the similarity of shape. This does not contradict the basic concept, for if the values were not relative, then changing the scale would not produce a similar curve.

Corresponding data for the rhomb-plate shape blends are presented in Fig. 43. In this case, the viscosities are shown for the 70% solids pigment slips. The general similarity in shape of this curve to the curves obtained by both centrifuging and filtration is evident.

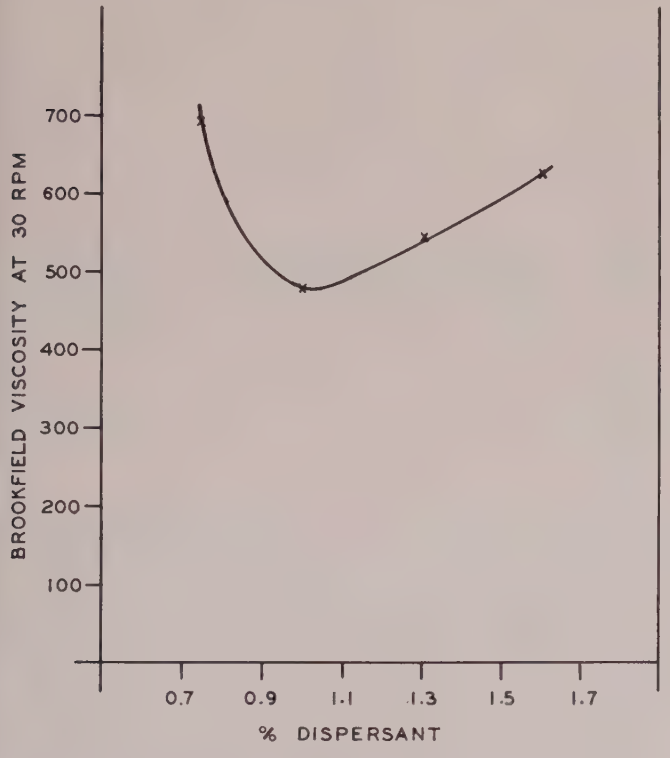

Fig. 36. Brookfield viscosity at 30 r.p.m. versus per cent dispersant

Needles—70% solids—Tamol 731.

The data indicate the possibility of developing mathematical formulations to predict relative sediment volume from viscosity as measured at low shear.

4. HERCULES VISCOSITY

The flow properties at high shear for the various shape blends were determined using the Hercules viscometer. The work was performed to demonstrate the relationship between particle packing and flow characteristics for the pigment dispersions. While rheograms were run at three solids levels—70, 65, and 60%—the effect of particle packing was not discernible from the rheograms run at the 65 and 60% solids levels.

For this reason, only the 70% solids data are presented. In Fig. 44, rheograms are shown for the needle-plate shape blends. The curves are labeled to indicate the composition of the mixtures. The upper figure represents the per cent needles; the lower figure, the per cent plates. The data illustrate do the relation-

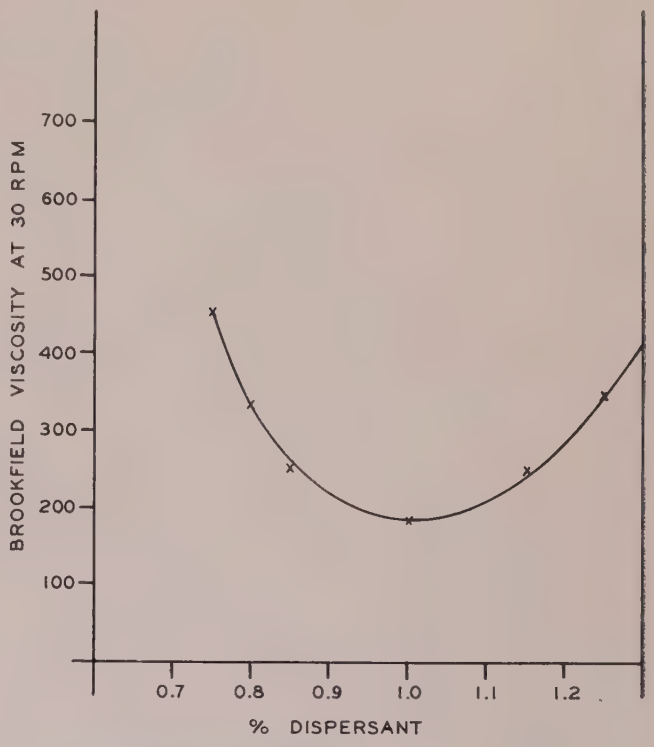

Fig. 37. Brookfield viscosity at 30 r.p.m. versus per cent dispersant

Rhombs—70% solids—Calgon T.

ship between particle packing and flow proper ties; however, it takes careful analysis of the rheograms to determine this fact.

In an attempt to more clearly portray the relationship, a plot was prepared of torque versus shape blend at constant revolutions per minute. Because of the high degree of dilatancy, exhibited, the relatively low speed of 100 r.p.m. was selected. The curve obtained by this method is shown in Fig. 45. As can be seen, the shape of this curve is quite similar to those determined by the other methods. The torque goes up rapidly to a maximum at the 20–80 needle-plate mixture. As the proportion of needles is increased beyond the 20% value, the Torque decreases rapidly at first, and then at a more gradual rate. This is the same characteristic shape as that determined by centrifuging pressure filtration, and Brookfield viscosity measurement.

The rhomb-plate shape blends were tested in a similar manner. The rheograms are shown in Fig. 46. The curves are labeled to indicate the composition of the mixtures. The upper figure represents the per cent rhombs and the lower figure, the per cent plates. Here again, the data illustrate the relationship between particle packing and flow properties, though not in a readily apparent manner.

Following the same procedure of plotting torque

versus shape blend at 100 r.p.m., the typical curve (Fig. 47) is obtained. The shape is similar to that obtained for relative sediment volume by centrifuging, filter cake

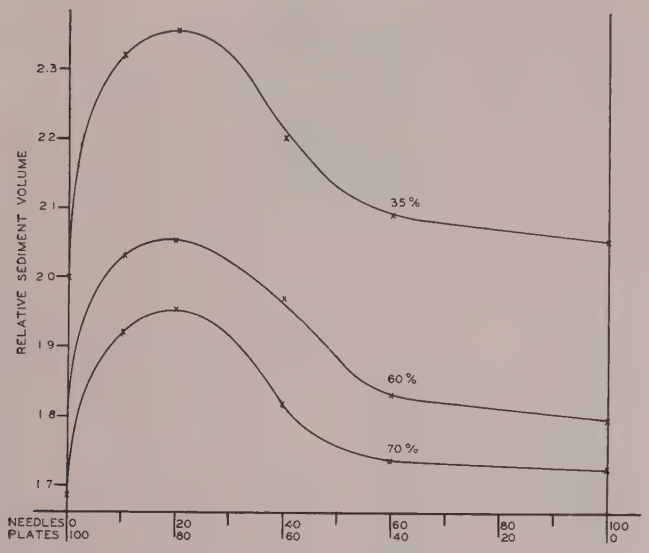

Fig. 38. Relative sediment volume versus shape blends
Needles—plates.

solids by pressure filtration, and viscosity at low shear by the Brookfield viscometer. The data indicate the possibility of developing mathematical formulations to predict relative sediment volume from viscosity as measured at high shear.

In view of the general agreement between the results of the various tests, it would seem that the packing tendencies observed are truly representative of the materials studied. Further, the possibility of using in-

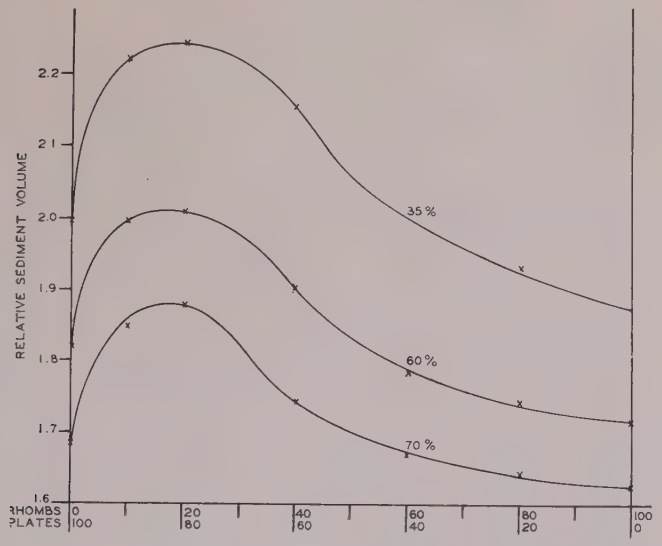

Fig. 39. Relative sediment volume versus shape blends
Rhombs—plates.

direct methods to determine the relative sediment volume of known systems should facilitate future work. If pigment particle packing in a coating color can be quickly ascertained by a simple viscosity measurement, then it will be relatively easy to determine what effect, if any, particle packing has on the final sheet characteristics.

5. DRAINAGE RATE BY PRESSURE FILTRATION SUMMARY

In an attempt to demonstrate the effect of particle packing on drainage rate, the time for water removal was noted during the pressure filtration work. The results obtained for the needle-plate shape blends are shown in the graph (Fig. 48). If the plot is inverted with respect to time, the resulting curve in some areas resembles that obtained for relative sediment volume. There is a rapid increase in the rate of water removal as the needle-shaped particles are introduced into the plate

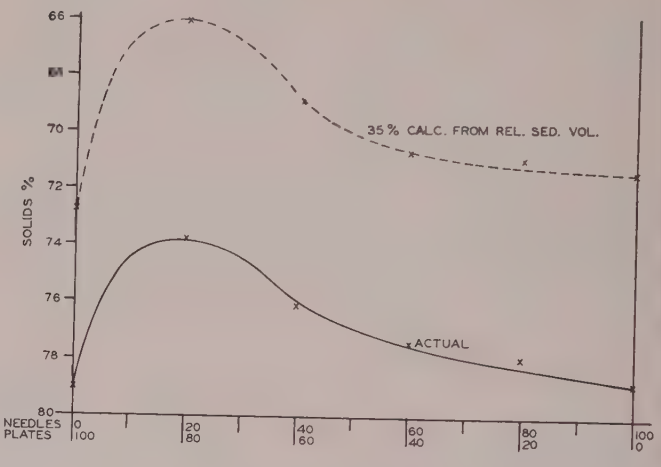

Fig. 40. Per cent solids in cake versus shape blends
Needles—plates.

system. Maximum rate or minimum time was found for the 20–80 needle-plate mixture. This corresponds to the maximum volume or minimum packing as ob-

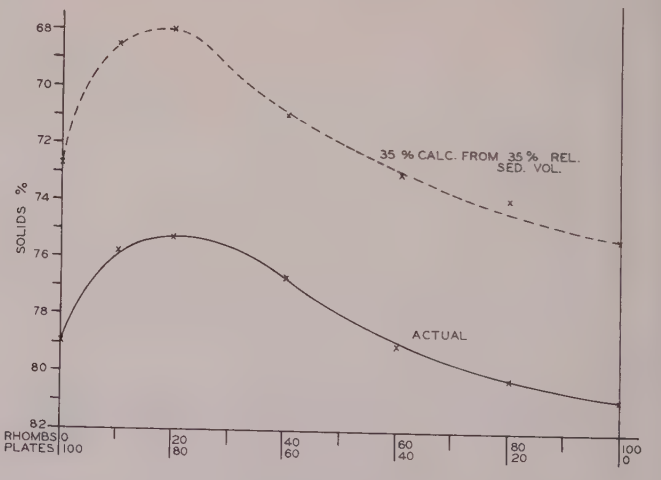

Fig. 41. Per cent solids in cake versus shape blends
Rhombs—plates.

served by the various methods of test. However, contrary to previous results, further increase in the needle portion of the blend did not produce a significant change in drainage rate. In the case of relative sediment volume, increasing the needle-shaped component produced a significant lowering in values.

Similar data for the rhomb-plate mixtures are shown in Fig. 49. The curve resembles that of relative sediment volume in some areas but does not conform in

others. It appears that there may be a correlation between particle packing and drainage rate, however, it is definitely not a simple relationship. Undoubtedly, other variables such as channeling and the like must be taken into consideration. The importance of drainage rate on coating color performance would seem to warrant further investigation in this area.

SUMMARY

1. The particle packing tendencies as measured by volume occupied by the pigment particles may vary widely depending upon conditions under which packing takes place and is influenced by the shape of the particles present.

2. For water dispersions of the pigment particles, the volume of sediment obtained by centrifuging indicates that relative sediment volume is influenced by the shape of the particles present in the original pigment slip.

3. In the particular systems investigated, dilution caused increased relative sediment volume but did not alter the general relationship between particle shape and volume.

4. Filter cake solids are influenced by the shape of the particles present in the original pigment slip. The relationship is similar to that obtained for relative sediment volume by centrifuging.

5. Filter cake solids are not influenced by dilution.

6. Brookfield viscosities of the pigments lips reflect the differences in particle packing observed and are influenced by the shape of the particles present in the original pigment slips.

7. Hercules viscosities of the pigment slips reflect the differences in particle packing observed and are influenced by the shape of the particles present in the original pigment slips.

In the systems investigated, it was observed that, the dry mixtures, water dispersions, and plastic models had different packing tendencies. The dry mixtures had increased packing as the percentage of plates was increased, while the plastic models had decreased packing as the percentage of plates was increased.

For the water dispersions, initially, packing decreased

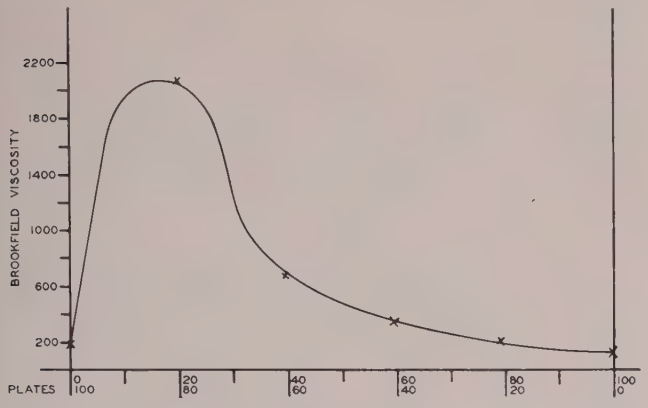

Fig. 42. Brookfield viscosity at 30 r.p.m. versus shape blends

Needles—plates—65% solids.

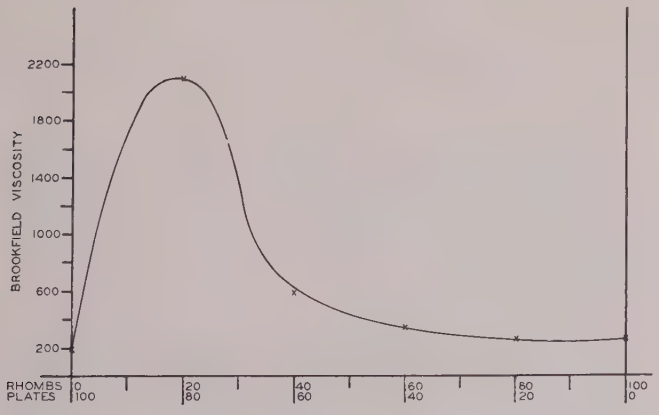

Fig. 43. Brookfield viscosity at 30 r.p.m. versus shape blends

Rhombs—plates—70% solids.

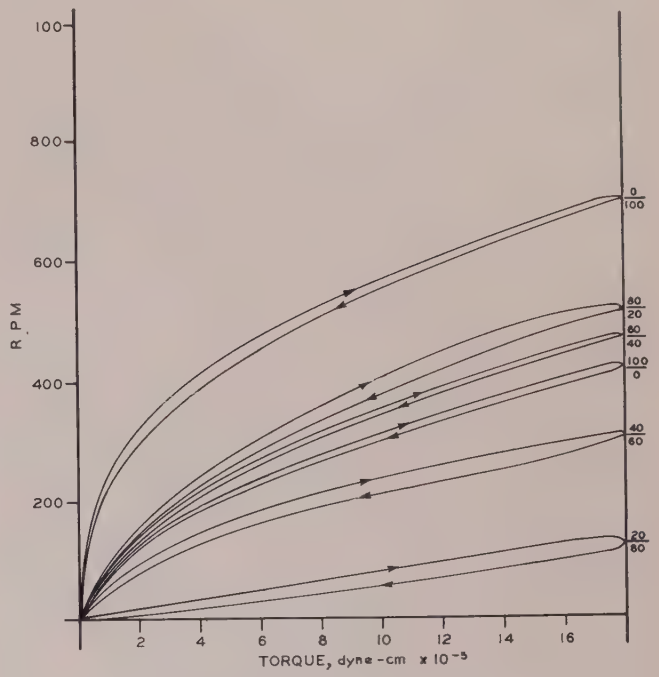

Fig. 44. Hercules hi-shear rheograms

Needles—plates—70% solids.

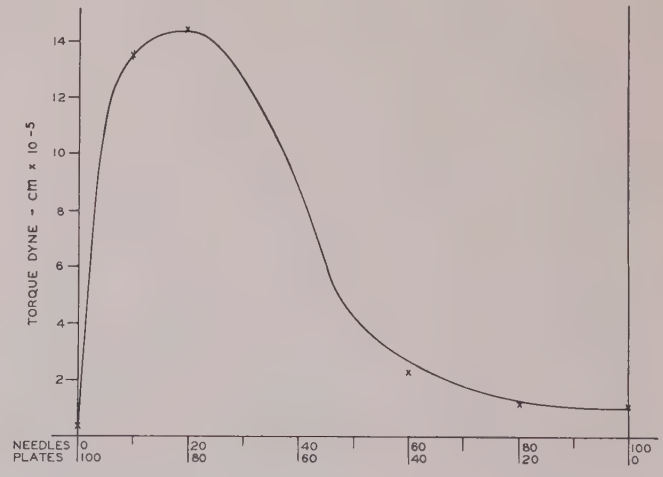

Fig. 45. Hercules torque at constant r.p.m. versus shape blends

Needles—plates—70% solids.

as either the needles or rhombs were added to the plate particles. This was indicated by the increase in the volume occupied by the pigment particles. In each

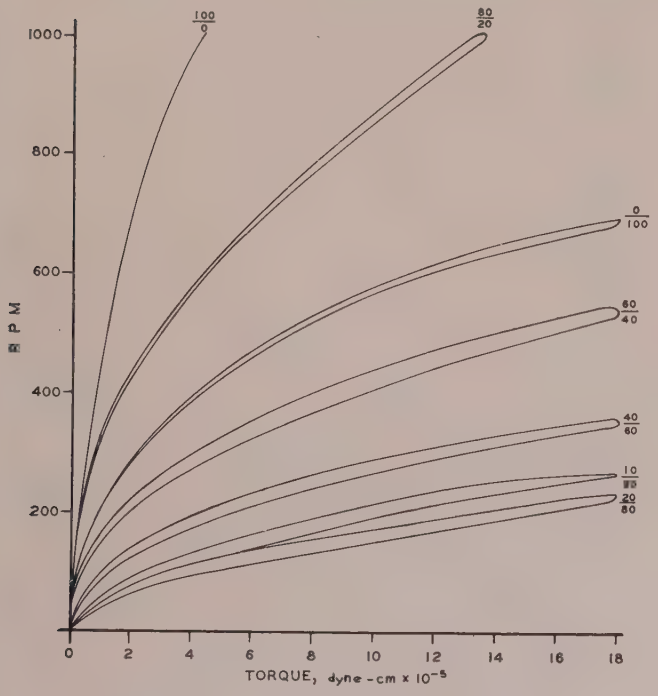

Fig. 46. Hercules hi-shear rheograms
Rhombs—plates—70% solids.

water system, the composition which exhibited maximum volume contained 80% plate particles. The curves for the two mixtures. . .needles-plates and rhombs-plates. . .are similar in shape for all methods of

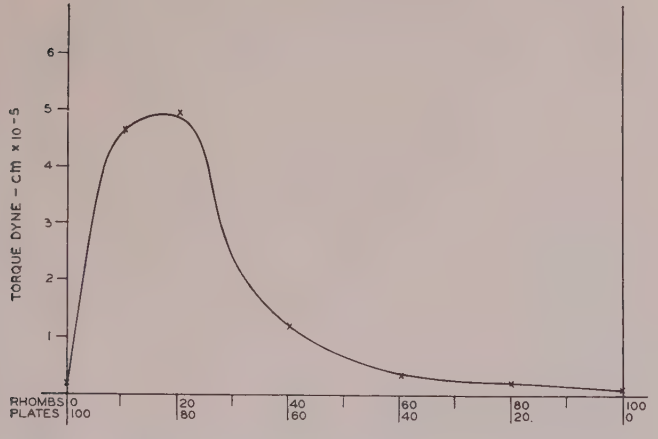

Fig. 47. Hercules torque at constant r.p.m. versus shape blends
Rhombs—plates—70% solids.

test. While there was a difference in the actual values obtained for the two mixtures, the significance of the difference has not been determined.

CONCLUSIONS

1. The shape of the pigment particle does influence its packing.

2. The effect of shape varies widely depending upon the system investigated.

3. For water systems, dilution, when accompanied by flocculation, results in decreased packing independent of particle shape.

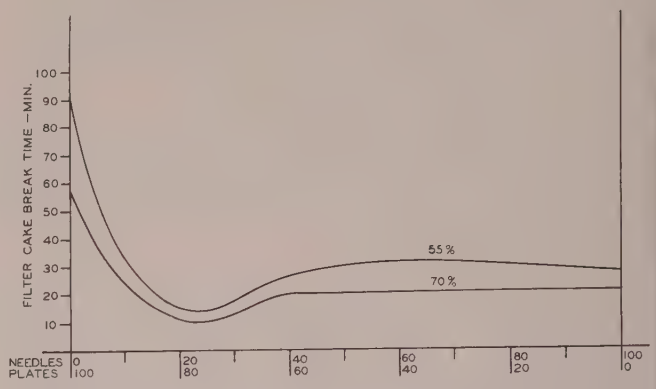

Fig. 48. Filter cake break time versus shape blends
Needles—plate.

4. Water drainage rate is probably influenced by particle shape but the relationship is not a simple one.

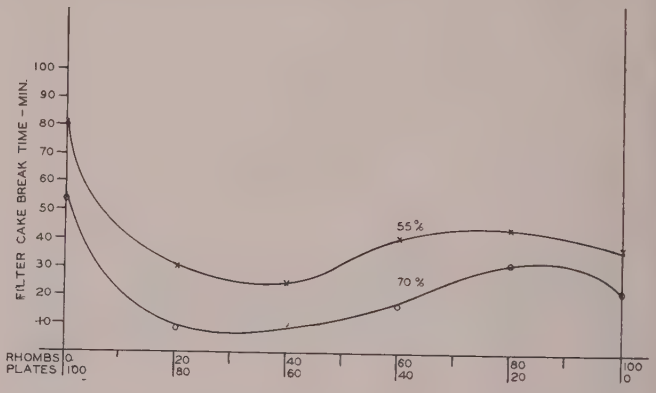

Fig. 49. Filter cake break time versus shape blends
Rhombs—plates.

5. Particle packing does influence the flow properties of pigment slips.

LITERATURE CITED

1. Furnas, C. C., The Relation between Specific Volume, Voids and Size Composition in Systems of Broken Solids of Mixed Sizes. Bureau of Mines Reports of Investigations, No. 2894 (1928), *Chemical Abstracts* 23: 1186.
2. Fraser, H. J., *J. Geology* 43, No. 8: part I, 910–1010 (Nov.-Dec., 1935).
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5. Hagemeyer, R. W. and Robinson, J. V., "The Effect of Pigment Combinations and Coating Solids on Particle Packing and Sheet Characteristics," TAPPI Project No. 600, Progress Report No. 2 (1959) (unpublished).

The committee would like to acknowledge the work of Adolph Damusis, J. W. Compton, and James White in making the determinations, and G. E. Hall and Mrs. E. Livingston in preparing the report.

The foregoing paper combines Progress Reports Nos. 1 and 2 by the subcommittee on Project 600 of the Coating Committee of TAPPI. R. W. Hagemeyer of Wyandotte Chemicals Corporation, James V. Robinson of the Mead Corp., Carl Kilpatrick of S. D. Warren, and Mr. Max Hughson of Provincial Paper Ltd. comprised at various times the above subcommittee.

The Coating Committee of TAPPI wish to acknowledge their thanks and appreciation for the work of the above people, as well as the time and effort of the Wyandotte Chemicals Corp., who freely gave their facilities and manpower to accumulate the data set forth in this report.

ASSOCIATION NEWS AND EVENTS

National Conferences

Eleventh Coating Conference, Edgewater Beach Hotel, Chicago, Ill., May 23–25, 1960.

Pulp Bleaching Conference, Edgewater Beach Hotel, Chicago, Ill., June 14–16, 1960.

Fourteenth Alkaline Pulping Conference, Multnomah Hotel, Portland, Ore., Aug. 22–24, 1960.

Forest Biology Conference, Seattle, Wash., Aug. 24–27, 1960.

Eleventh Testing Conference, Pantlind Hotel, Grand Rapids, Mich, Sept. 27–29, 1960.

Fifth Deinking Conference, Conway Hotel, Appleton, Wis., Oct. 5–7, 1960.

Tenth Corrugated Containers Conference, Royal York Hotel, Toronto, Canada, Oct. 10–13, 1960.

Fifteenth Plastics-Paper Conference, Hotel Syracuse, Syracuse, N. Y., Oct. 17–19, 1960.

Fifteenth Engineering Conference, Robert Meyer Hotel, Jacksonville, Fla., Oct. 24–28, 1960.

Local Section Meetings

Pacific: April 28, 29, 30, 1960, Bellingham, Wash., Annual Meeting; September, 1960, Salem, Ore., "Modernization."

Golden Gate District (Pacific Section): March 29, 1960, "Recent Advances in Materials Handling," 4:00 p.m. mill visit to Nulaid plant, dinner at Cottage Restaurant, San Leandro 6:00 p.m. May 10, 1960, True Memorial Lecture, Hotel Claremont, Berkeley.

Lakes States: April 12, 1960, dinner location to be announced. Theme: C. J. West Awards. May, social meeting—date to be announced.

Delaware Valley: March 26, 1960, Benjamin Franklin Hotel, Philadelphia, Pa., 1960 Philadelphia Graphic Arts Conference, April 28, 1960, Engineers Club, Philadelphia, Pa., E. J. Albert Award Program; May 27, 1960, Beloit Eastern, Downingtown, Pa., tour and outing.

Kalamazoo Valley: April 21, 1960, Inman's Restaurant, Galesburg, "Stock Preparation"; May 12, 1960, Harris Hotel, Kalamazoo, Recognition Night, WMU Awards; June 21, 1960, Annual Golf Outing, Gull Lake Country Club.

New England: April 8, 1960, Management Night; June 3–4, 1960, Chatham Bars Inn, Chatham, Mass., Spring Meeting.

Ohio: April 12, 1960, Miami University, Oxford, Ohio, a tour of the new Paper School. Subject: "High Polymers." Speaker: H. E. Whitacre. May 12, 1960, Hartwell Country Club, Cincinnati, Ohio, Ladies' night.

Ohio (Indiana District): April 19, 1960, Plant tour to be announced, "Coating," Brage Golding, Purdue University. May 17, 1960, Marott Hotel, Indianapolis, Ind., "Testing," Arthur Dreshfield, The Glidden Co.

Empire State: Whiteface Inn, Whiteface, N. Y., June 10–11, 1960.

Empire State (Metropolitan District): 465 Lexington Ave. New York, N. Y.; April 12, 1960, "Packaging"; May 13, 1960, Ladies' Night.

Empire State (Northern District): Woodruff Hotel, Watertown, N. Y. April 14, 1960, Junior Award Night; May 12, 1960, Annual Ladies' Night.

Empire State (Central District): University Club, 431 E. Fayette St., Syracuse, N. Y.

Empire State (Western District): Prospect House, Niagara Falls, N. Y.

Empire State (Eastern District): Queensbury Hotel, Glens Falls, N. Y. April 21, 1960, Symposium, "Wet End Machine Operation"; May 21, 1960, Annual Ladies' Night.

Maine-New Hampshire: June 17–18, 1960, Mountain View House, Whitefield, N. H., Annual Meeting.

Chicago: Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill. April 5, 1960, Corrugating; May 3, 1960.

Southeastern: May 20–21, 1960, Savannah, Ga.

Gulf Coast: May 13, 1960, New Orleans, La.

Electrical Engineering Committee

S. Andersen, West Virginia Pulp and Paper Co., New York, N. Y., chairman of the Electrical Engineering Committee was announced the committee will hold an interim meeting on April 20, 1960, at the University of Florida, Gainesville, Fla., at 9:00 a.m.

As has been the practice of the committee during the past years, the spring interim meeting is again being held adjacent to the AIEE Annual Conference on Electrical Engineering in the Pulp and Paper Industry.

The AIEE conference is scheduled for April 21–22, 1960, at the University of Florida. A résumé of the AIEE program follows.

Mr. Andersen has prepared a full agenda of items for the committee meeting which will be distributed to members and he would urge all members to attend the meeting if at all possible.

WEDNESDAY, APRIL 20, 1960

1–5 p.m. Registration—Dobby, McCarty Hall Auditorium, University of Florida

THURSDAY, APRIL 21, 1960

Morning Session

8:30 a.m. Registration—Lobby, McCarty Hall Auditorium, U. of Fla.

9:30 a.m. Conference Opening—McCarty Hall Auditorium, U. of Fla. C. H. Hudson, chairman, Pulp & Paper Subcommittee, General Electric Co., Atlanta, Ga.

Address of Welcome—Joseph Weil, Dean, College of Engineering, U. of Florida

Presiding: JAMES J. BERRY, *Chairman,* Jacksonville, AIEE Section, Smith & Gillespie, Consulting Engineers

10:00 a.m. "Surge Protection in Paper Mills," H. B. Greear, General Electric Co., Atlanta, Ga.

10:40 a.m. Recess

11:00 a.m. "Pulse-Digital Regulating System for Paper Machine Drives," R. P. Derrick and C. L. Ivey, Westinghouse Electric Corp.

12:30 p.m. Luncheon, Holiday Inn Motel, Gainesville, Fla.

Afternoon Session

Presiding: E. H. OVERBY, Union Bag-Camp, Paper Corp., Savannah, Ga.

2:30 p.m. "Crane and Hoist Systems," Fred Fisher, Whiting Corp., Charlotte, N. C.

3:10 p.m. Recess

3:20 p.m. "Low Voltage A.C. Motor Insulating Panel," Panel Chmn., E. K. Murphy, Rayonier, Inc., Jesup, Ga.

Panel Members

R. J. Dineer, Allis-Chalmers Co., Milwaukee, Wis., "Class B Insulation Systems"

E. W. Summers, Westinghouse Elec. Corp., Buffalo, N. Y., "Class F&H Insulation Systems"

B. M. Brissey, General Electric Co., Schenectady, N. Y., "New Insulation Varnishes and Resins"

E. C. Barnes, Reliance Elec. & Engrg. Co., Cleveland, Ohio, "Purpose of Coil Encapsulation"

W. P. Gettleman, Louis-Allis Co., Milwaukee, Wis., "Pulp & Paper Insulation System Selection"

Evening Session

6:00 p.m. Social Hour—Sponsored by manufacturers
7:00 p.m. Dinner. Toastmaster—E. S. Lammers, University of Florida

FRIDAY, APRIL 22, 1960

Morning Session

Presiding: J. M. YARBROUGH, Mead Corp., Chillicothe, Ohio
9:30 a.m. "Controlling Atmospheres for Paper Mill Control & Switchgear," John R. Stevens, Champion Paper, Canton, N. C.
10:15 a.m. Recess
10:30 a.m. "Installation and Testing of Transistorized Equipment in Paper Mills," R. D. Clarke, Brown Instrument Co.
11:15 a.m. "Selection and Storage of Critical Parts and Replacement in a Paper Mill Electrical System," W. H. Buford, Southern Advance Bag & Paper Div., Continental Can Co., Hodge, La.

Afternooon Tours

2:00 p.m. Inspection Trips: University of Florida, Pulp & Paper Laboratory; Buckeye Cellulose,* Foley, Fla.; Hudson Pulp & Paper,* Palatka, Fla.; Owens-Illinois Glass,* Jacksonville, Fla.

LADIES' PROGRAM

THURSDAY, APRIL 21, 1960

9:45 a.m. Coffee Hour—Holiday Inn
10:30 a.m. Trip to Silver Springs, Fla.

1960 Conference—Study Group of European TAPPI Members

The following provisional arrangements have been made.

Place and Date: Lucerne, Switzerland. September 12–16, inclusive.

Fee: To be notified; but, excluding dinners and excusions, not exceeding 80 Swiss francs (£6.15.0d.).

Organization: All queries concerning hotels, etc., will be organized by R. Naville, Jenataschstrasse 4, Zürich 2, Switzerland, and the Lucerne Travel Bureau.

All queries concerning the program should be sent to the secretary, I. F. Hendry, Butler's Court, Beaconsfield, Bucks., England.

Program: The following program has been suggested. It is hoped to arrange for the European authority on each subject to give the paper. Because of this there is very little time available for other papers. However, if you are a European expert on any of the subjects mentioned and wish to give a paper critically reviewing the situation, you should contact Mr. Hendry. The Committee cannot, however, guarantee to accept any papers which may be offered.

MONDAY, SEPTEMBER 12

A Review of Papermaking.

1. The problems of high speed machines.
2. The problems of sheet formation.
3. The problems of sheet transfer.
4. The problems of sheet drying.
5. The problems of machine control and instrumentation.

A panel of educational experts from Austria, Germany, France, Great Britain, and Scandinavia will discuss formal education and training of paper mill staff in their countries.

Following this, a panel of industrialists will discuss whether the education facilities are adequate.

Finally the audience will have an opportunity of questioning both panels.

* Arrangements have been made with these mills that any person attending the Conference who visits the mills on Wednesday, April 20, or Friday p.m., April 22, will be given a guided tour through the mill.

TUESDAY, SEPTEMBER 13

Two papers will be presented and discussed:

1. How to introduce the educated man into the pulp and paper industry and make the best use of his abilities.
2. The efficient utilization of research ideas in the practical field.

WEDNESDAY, SEPTEMBER 14

A review of the sulfite pulp industry and of pulp bleaching techniques.

Meeting of TAPPI members.

THURSDAY & FRIDAY, SEPTEMBER 15 & 16

Visits to Atiesholz pulp mill, and Utsendorf, Deiswell and Cham mills.

1960 TAPPI Executive Committee

As reported by the Tellers Committee, James R. Lientz, Union Bag-Camp Paper Co., Savannah, Ga. and Harold M. Annis, Oxford Paper Co., New York, N. Y., were elected president and vice-president, respectively, of the Association.

Joining them on the Executive Committee are four new men who have just been elected to serve three-year terms: J. M. McEwen, Weyerhaeuser Co., Everett, Wash.; A. H. Nadelman, Western Michigan University, Kalamazoo, Mich.; K. D. Running, Halifax Paper Co., Roanoke Rapids, N. C., and H. A. Spencer, Knowlton Bros., Watertown, N. Y.

The Executive Committee members whose terms expired in February, 1960, are B. T. Briggs, Rayonier, Inc., Shelton, Wash.; K. G. Chesley, The Crossett Co., Crossett, Ark.; J. R. Curtis, Scott Paper Co., Chester, Pa., and J. P. Weidner, Container Corp. of America, Brewton, Ala.

Report of the 1960 Tellers Committee

The Tellers Committee has submitted the following report to the secretary on the 1960 election of Association officers.

"We, the members of the Tellers Committee, having made a canvass of the official ballots for officers and members of the Executive Committee for 1960 of the Technical Association of the Pulp and Paper Industry have found that the following persons have received a majority of 1445 votes cast out of 1536 received."

President: James R. Lientz, Union Bag-Camp Paper Co., Savannah, Ga.
Vice-President: Harold M. Annis, Oxford Paper Co., New York, N. Y.
Executive Committee (to serve three years):
J. M. McEwen, Weyerhaeuser Co., Everett, Wash.
A. H. Nadelman, Western Michigan University Kalamazoo, Mich.
K. D. Running, Halifax Paper Co., Roanoke Rapids, N. C.
H. A. Spencer, Knowlton Bros., Watertown, N. Y.

A. D. Bonnano, *Chairman*
G. C. Inskeep
F. R. Marchetti

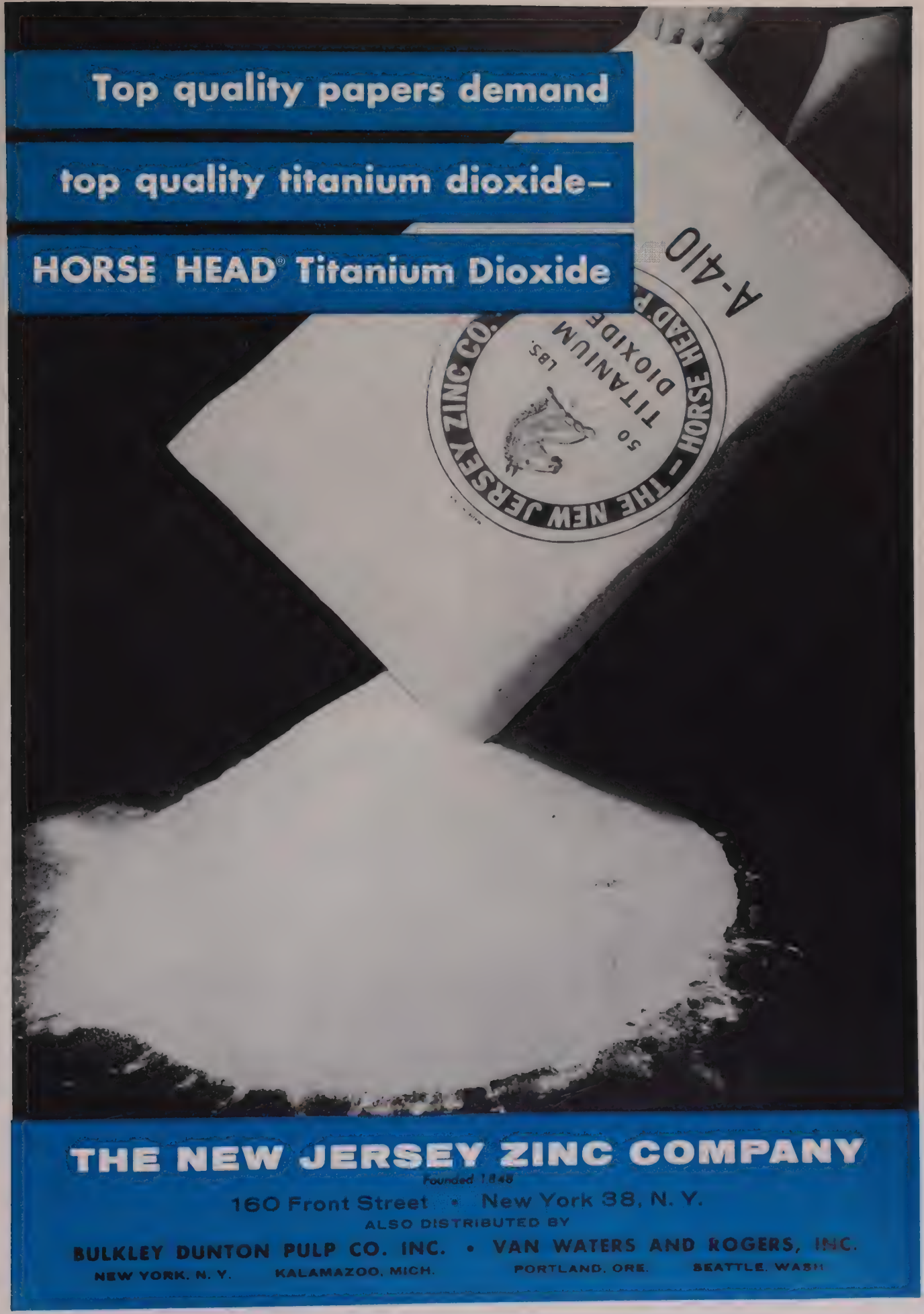
TAPPI Editorial Board

The following have accepted nominations for a 3-year term on the *Tappi* Editorial Board. Insofar as possible, these men represent the same interests as those that they replace so that over-all balance of the Board will be maintained.

Claud B. Christiansen, Pulp and Paper Laboratory, Diamond Alkali Co., Painesville, Ohio. (J. G. L. Caufield—Pulping)

J. W. Gilbert, Director of Research, International Paper Co., Mobile, Ala. (H. S. Gardner—Research)

Edward G. Locke, Director, Forest Products Laboratory, Madison, Wis. (J. R. Salvesen—Lignin, Wood, and By-Products)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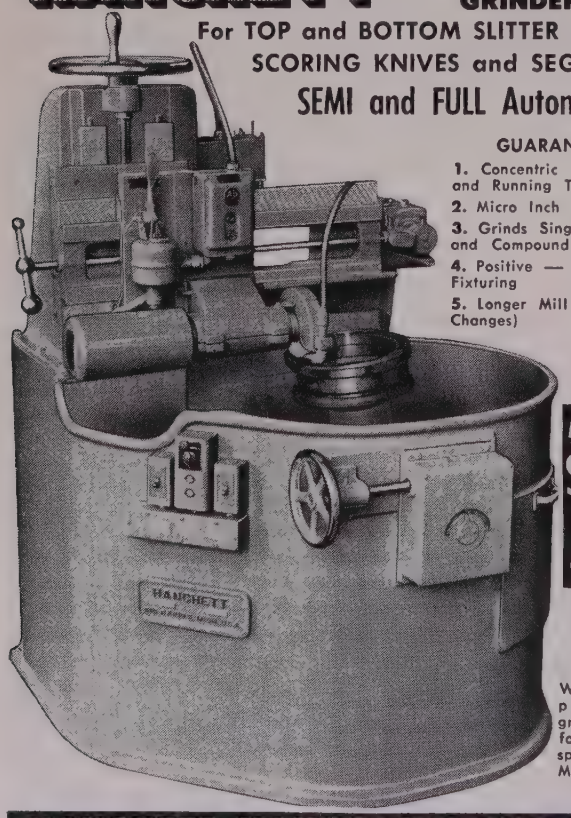

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G. G. Maltenfort, Technical Director, Container Division Laboratory, Container Corp. of America, Chicago, Ill. (R. A. McKee—Containers)

M. N. May, Manufacturing Manager, Gulf States Paper Corp., Tuscaloosa, Ala. (M. L. Taylor—Kraft Mill Operation)

R. H. Mosher, Assistant Sales Manager, Technical Papers Division, Kimberly-Clark Corp., Neenah, Wis. (J. C. Rullman—Plastics-Paper)

J. F. Theriault, Robert Gair Division, Continental Can Co., Uncasville, Conn. (R. H. Doughty—General Mill and Beater Additives)

J. Weiner, The Institute of Paper Chemistry, Appleton, Wis. (Holdover—General and IPC Liason)

Career Guidance Brochure

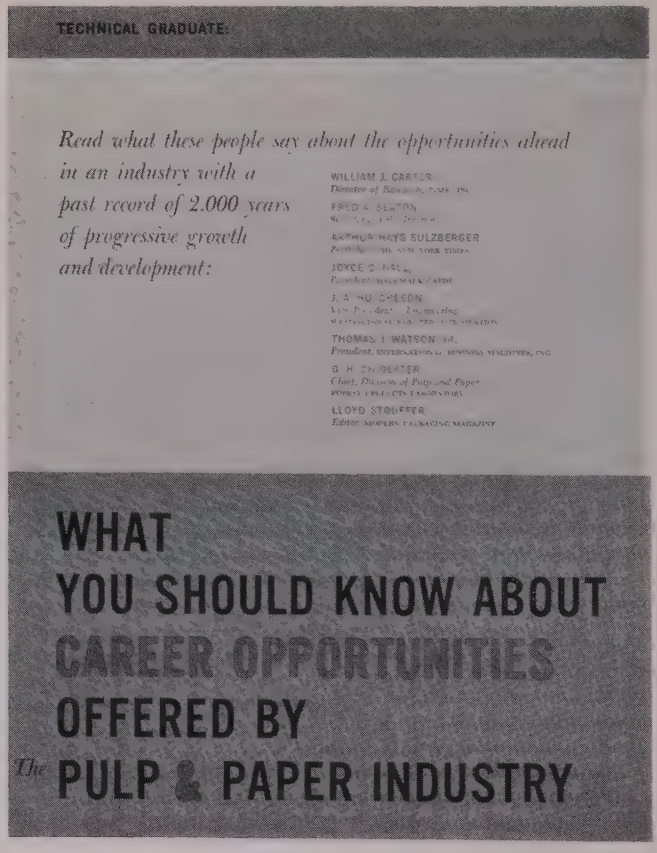
A comprehensive career guidance brochure entitled: "What You Should Know About Career Opportunities Offered by the Pulp and Paper Industry," has just been issued by TAPPI.

The brochure is aimed at students and technical graduates in science and engineering and related fields. It outlines career opportunities in this, the country's ninth largest manufacturing industry.

The brochure highlights several of the many facets of the technical work done by pulp and paper companies and allied organizations. This is accomplished with a number of definitive articles prepared by industry leaders, government agencies, major paper procedures, and other organizations directly and indirectly concerned with research and uses of paper and paper products.

The booklet also presents a background history of the industry and its growth, a projection of future potential, and a detailed analysis of the specific types of career opportunities open to graduates with science and engineering degrees.

TAPPI is composed of close to 10,000 people engaged in technical work in the pulp, paper, and allied industries in this country and abroad, and is well qualified to point out the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WHAT YOU SHOULD KNOW ABOUT CAREER OPPORTUNITIES OFFERED BY The PULP & PAPER INDUSTRY

technical opportunities in the field. The Association was founded in 1915, and among its many functions are the preparation and dissemination of testing standards and technical publications, and the sponsorship of research projects and a series of annual national and regional technical conferences.

The new career guidance brochure is a 36-page, three-color production, using both artwork and photography. It is available upon written request from the Technical Association of the Pulp and Paper Industry, 360 Lexington Ave., New York 17, N. Y.

Eleventh Coating Conference

The Eleventh Annual TAPPI Coating Conference will be held at the Edgewater Beach Hotel, Chicago, Ill., May 23–25, 1960.

A highlight of the conference will be a panel discussion on "Coating for Printing," to be sponsored by TAPPI Graphic Arts Committee.

The moderator for this session will be Walter W. Roehr, Kimberly-Clark Corp.

The industry members are:

Letterpress and Rotogravure Printing: Philip C. Evanoff, The Mead Corp.

Offset Printing: Alger P. Reynolds, S. D. Warren Corp.

Coated Board Printing: Willard I. Stinger, Marathon Corp.

The Graphic Arts members are:

Offset Printing: Charles H. Borchers, Lithographic Technical Foundation Inc.

Rotogravure Printing: Frederick W. Goetz, Publication Corp.

Coated Board Printing: Victor J. Porth, Robert Gair Paper Group, Continental Can Corp.

Letterpress Printing: Marvin C. Rogers, Chicago Paper Testing Laboratory.

Papers to be presented:

1. "Electrostatic Coating Process for Making Flat Gummed Paper," by F. W. Holt and C. L. Lorenz, Brown Bridge Mills, Inc., and R. B. Reif, Battelle Memorial Institute.
2. "European Approach to Printability Research," by M. C. Rogers, Chicago Paper Testing Lab.
3. "A Laboratory Instrument for Measuring the Filing Propensity of Papers Used in Offset Lithography," by Frank F. Oehme and Don C. Nepper, Consolidated Meter Power and Paper Co.
4. "Design and Operation of Pilot Plant Coaters," by E. D. Jones, Crossett Paper Mills, and N. H. Laughery, Black-Clawson Co.
5. "Operating Variables of a Blade Coater," by W. J. Follette and R. W. Fowells, Crown Zellerbach Corp.
6. "New Surface Sizing Technique with Polyvinyl Alcohol," by B. A. Beardwood and E. P. Czerwin, E. I. du Pont de Nemours and Co.
7. "Coating Polymers for Paper Products," by W. L. Boyer, Firestone Plastics Co.
8. "A New Precision Technique for Measurement of Coating Thickness," by H. H. Murray, Georgia Kaolin Co., and W. D. Johns, Washington University.
9. "The Effect of Mixing Intensity on the Dispersion of Coating Pigments in Water," by N. Millman and J. B. Whitley, J. M. Huber Corp.
10. "A Method to Determine the Degree of Web Rub Resistance," by F. Ray Adams, Jr., International Paper Co.
11. "The Effect of Pigment Binders on Paper Gloss, Printed Gloss and Oil Absorption," by R. E. Weber, Kimberly-Clark Corp.
12. "Electron Micrographic Examination of Coated Paper Rated as to Printability," by F. M. Mong and H. G. Guy, Koppers Co, Inc.
13. "Surface Strength Studies," by J. M. Fetsko, Lehigh University.
14. "New Developments in Offset Printing," by M. Bruno, Lithographic Technical Foundation.
15. "Pressure Cooking for Coating Color Preparation," by W. C. Black and V. L. Winfrey, Penick and Ford Ltd., Inc.
16. "Electronic Printability Scanner," by W. C. Walker, West Virginia Pulp and Paper Co.

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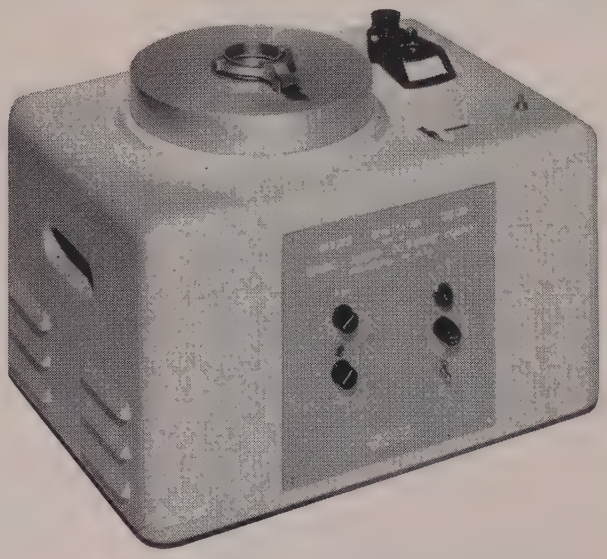

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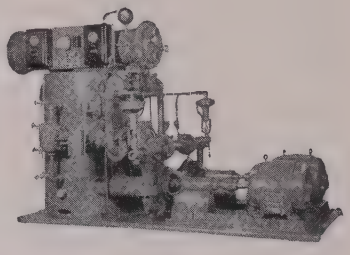

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General chairman of the conference is R. W. Hagemeyer, Wyandotte Chemicals Corp., Wyandotte, Mich. Technical program chairman is R. W. Martinek, Kimberly-Clark Corp., Neenah, Wis. W. E. Welliver, New York and Penn. Co. Inc., Lock Haven, Pa. is publicity chairman, and local arrangements chairman is C. W. Cairns, The Dow Chemical Co., Midland, Mich.

Reservations for sleeping accommodations during the conference should be addressed to the Edgewater Beach Hotel Chicago, Ill.

Forest Biology Symposium

A Forest Biology Symposium, sponsored by the TAPPI Forest Biology Committee, will be held Aug. 24–26, 1960, at the New Washington Hotel, Seattle, Wash.

The three-day conference will be designed to attract both woodlands men and mill people interested in wood quality, and special sessions will be devoted to discussion of problems shared by both mill men and foresters.

R. J. Seidl, Simpson Timber Co., Seattle, Wash., is general chairman of the symposium, and the technical program is being prepared by J. W. Duffield, W. B. Greely Forest Nursery, Nisqually, Wash. Local arrangements will be handled by R. Z. Callaham, U. S. Forest Service, Inland Empire Research Center, 5175 Howard Street. Spokane, Wash. A. J. Winchester, TAPPI, New York, will act as treasurer and publicity director for the conference.

Tenth Corrugated Containers Conference

The Tenth Corrugated Containers Conference, which is jointly sponsored by TAPPI and Canadian Pulp and Paper Association, Technical Section, is scheduled to be held Oct. 10–13, 1960, at the Royal York Hotel, Toronto, Ont.

The conference will consist of technical sessions on October 11 and 12, with committee meetings scheduled for October 10, and a mill tour for October 13.

R. W. Buttery, Bathurst Containers Ltd., Montreal, Que., (chairman of the TAPPI Corrugated Containers Division Production Committee) is general conference chairman. Other members of the conference arrangements committee are treasurer, H. O. Teeple, TAPPI, New York, N. Y.; secretary, D. M. Farrell, Bathurst Containers, Ltd., Montreal, Que.; technical program, Mr. Buttery and R. H. McGee, Bathurst Power and Paper Co., Ltd., St. Laurent, Que.; publicity W. G. James, St. Lawrence Corp., Montreal, Que.; local arrangements chairman, W. J. Hurrell, Hinde and Dauch Paper Co. of Canada, Ltd., Etobicoke, Que.; registration, E. H. Head, Bathurst Containers Ltd., Toronto, Ont.; hotel arrangements, S. M. Johnson, Gair Paper Products, Div. Continental Can Co., Ltd., Toronto Ont.; hotel arrangements, S. M. Johnson, Gair Paper Products, Div. Continental Can Co., Ltd., Toronto, Ont.; and mill tours, H. S. Goodwin, Bathurst Containers Ltd., Toronto, Ont.

R. A. Joss, Canadian Pulp and Paper Association, Technical Section and H. O. Teeple, TAPPI are acting in advisory capacity for the jointly sponsored conference.

B. Mendlin, Cornell Paperboard Products, Milwaukee, Wis., is chairman of the TAPPI Corrugated Containers Division and R. H. McGee is chairman of the Corrugated Containers Committee of CPPA, Technical Section.

29th Annual Meeting—Inter-Society Color Council

The 29th Annual Meeting of the Inter-Society Color Council will be held at the Philadelphia Museum College of Art, Philadelphia, Pa., on Monday and Tuesday, April 11 and 12, 1960.

On Monday, April 11, meetings of the color problems subcommittees will be held.

The annual business meeting will be on Tuesday morning, April 12. During the afternoon a symposium will be held under the general title of "Creative Color." The three speakers for the symposium are:

Neil Welliver, Asst. Professor, Dept. of Art, Yale University
Lester Beall, Designer, Brookfield Center, Conn.
Robert Riley, Director, Industrial Research Division, The Brooklyn Museum

The banquet will be held on Tuesday evening in the Arenberg Gallery of the Philadelphia Museum of Art, followed by an illustrated lecture in the

Van Pelt Auditorium of the museum given by James Johnson Sweeney, director, Solomon R. Guggenheim Museum, New York City.

Advance registration blanks may be obtained by writing Ralph M. Evans, secretary, Inter-Society Color Council, Color Technology Division, Building 65, Eastman Kodak Co., Rochester 4, N. Y.

Finnish Paper Engineers' Association

The Finnish Paper Engineers' Association will hold its Annual Meeting on April 21–22, 1960, in Helsinki, Finland.

The first day of the meeting consists of panel discussions of the seven sections of the association. During the second day general papers will be given, one from Norway, one from Sweden, and one from England.

The association will be delighted to receive any TAPPI members who happen to be in Finland at the time of the meeting.

Third Cellulose Conference

A cellulose conference will be held at Syracuse on Oct. 27 and 28, 1960. Those who wish to contribute a paper at this Conference are requested to send their application to the Cellulose Research Institute, State University College of Forestry, at Syracuse University, Syracuse 10, N. Y., as soon as possible, but not later than May 1, 1960.

Three copies of a 200 to 300-word abstract should reach the Cellulose Research Institute before Aug. 1, 1960. The complete manuscript should be submitted before Oct. 1, 1960.

The subject of the papers must pertain directly or indirectly to cellulose, and must be of a fundamental nature. This means that papers which are concerned merely with technical data for which no scientific background has (yet) been found, will be excluded. A committee will decide whether papers are, on these grounds, acceptable or not. This committee reserves the right to refuse a contribution if it is considered unsuitable.

The contributions will be published in the *Journal of Polymer Science* at the end of 1960 or the beginning of 1961. The proceedings of the conference will be available in the form of the journal's issue.

University of Maine—Summer Institute for the Pulp and Paper Industry

The first session of the Summer Institute for the Pulp and Paper Industry will be held during the summer of 1960 at the University of Maine. The institute is being sponsored by The University of Maine Pulp and Paper Foundation and will offer a program designed to broaden the technical and management training of people associated with the pulp and paper industry.

It is expected that administrators, supervisors, and key operating personnel of pulp and paper mill operation as well as persons employed by the many supplier industries will find the Institute a valued means of enhancing their technical and managerial potentialities.

Two programs, each lasting three weeks are to be given. Persons may enroll for either or both of these sessions. The first session of the Institute will be given July 11 through 29 and the second session will be held August 1 to 19. Courses offered during both sessions will cover technology, manufacturing, testing, and management. However, the first session will stress pulping subjects and during the second session paper subjects will be treated.

Five well known educators in the field of pulp and paper technology as well as noted industrialists from among the directors of The University of Maine Pulp and Paper Foundation will join with members of the resident staff at Maine to give instruction at the Summer Institute for the Pulp and Paper Industry.

Visiting educators will be:

Professor John Lewis, formerly Head, Department of Paper Engineering, Lowell Technological Institute.

Professor C. Earl Libby, Head, Pulp and Paper Technology, North Carolina State College.

Dr. Alfred H. Nadelman, Head, Department of Paper Technology, Western Michigan University.

Professor Frederic W. O'Neil, Head, Department of Pulp and Paper Technology, State University of New York, College of Forestry.

Dr. Roy P. Whitney, Dean, The Institute of Paper Chemistry.

Weekly lectures by some of the 28 directors of The University of Maine Pulp and Paper Foundation will be given. These lectures will cover

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subjects dealing with management considerations of manufacture, organization, and personnel.

Resident staff for the Summer Institute will consist of:

Professor Lyle C. Jenness, Institute Director, Head, Department of Chemical Engineering.

Associate Professor Andrew J. Chase, Department of Chemical Engineering.

Assistant Professor John F. Gorham, Department of Chemical Engineering.

Those attending the Institute will be housed at Hart Hall, one of the newest campus dormitories, unless they prefer to live off campus. Both single and double rooms are available and meals will be provided at The Commons, a modern and attractive dining hall. A "get acquainted" dinner will be held at The Commons on Sunday, July 10, for the first session and on Sunday, July 31, for the second session.

All classes with the exception of field trips will be held in Aubert Hall. One or more trips will be made each week to a pulp or paper mill. A certificate signed by the president of the University of Maine and the president of The University of Maine Pulp and Paper Foundation will be presented at a luncheon the last day of each program to each person who satisfactorily completes the program.

Requests for further information concerning the summer institute should be addressed to: Professor Lyle C. Jenness; Director, Summer Institute for the Pulp and Paper Industry, Aubert Hall, University of Maine, Orono, Me.

ATIP

The Association Technique de L'Industrie Papetiere will hold its Annual Meeting, 13th Congress, May 29–June 3, 1960, at Aix-les-Bains (Savoie). Program details may be obtained from Paul Turel, Secretary General, Association Technique de L'Industrie Papetiere, 154, Boulevard Haussmann, Paris, France.

1960 Tappi Standards Index

The following corrections should be made in the 1960 TAPPI Standards Index.

T 218 m-59—index reads *1958*
T 409 m-35—index reads *1953*
T 441 m-58—index reads *1959*

1960 TAPPI Medal Presentation

Remarks by H. F. Lewis

Mr. President, Members of TAPPI, and Guests:

For the second time I have been asked to present the TAPPI Medal to the recipient selected by the TAPPI Executive Committee. On the first occasion, 23 years ago, it was my privilege to introduce to the members of TAPPI, C. J. West. Today we honor Louis Elsberg Wise who bears the double title of Emeritus Professor, College of Forestry, State University of New York and Senior Research Associate, The Institute of Paper Chemistry.

In what follows, I am greatly indebted to Dean Edwin C. Jahn of the College of Forestry, State University of New York for much I will say about our medalist in his relation to this institution.

Doctor Wise is a native of New York by birth and schooling. He received his B.A. from Columbia University in 1907 and his Ph.D. (in Organic Chemistry) from the same institution in 1911. Between 1911 and 1919 when he became Professor of Forest Chemistry at what was then called the New York State College of Forestry at Syracuse, he tried his hand at a number of different kinds of scientific work. First came industry; for a period he was a research chemist with the pharmaceutical firm of W. A. Schiefflen. From there he went to the Standard Varnish Works also as a research chemist; it was during this period that he first became interested in resins and the extraneous materials of wood. This was followed by a year as Instructor in Biochemistry at Columbia University, and then the following year he taught General Chemistry at the University of Missouri. In 1914 he joined the Pharmacological Division of the U.S.D.A. Bureau of Chemistry in Washington, was later transferred to the Bureau of Plant Industry and in 1918 was put on the staff of the Science and Research Division of the Signal Corps of the War Department working in the facilities of the Color Investigation Laboratory of the Bureau of Chemistry on the synthesis of photosensitizing dyes. It was there that our paths first crossed, for at that time I was a member of the staff of the Color Investigation Laboratory studying dyestuff crudes and intermediates. Little did I realize how often our paths would continue to cross from that day on. At the conclusion of the war, Dr. Wise spent a short time in the Du Pont Research Department.

In the fall of 1919, he started his long career in wood chemistry as Professor of Forest Chemistry at the New York State College of Forestry. He remained in this connection for about 13 years. During this time he assisted in getting underway the program in pulp and paper and taught various aspects of wood chemistry under the title of Forest Chemistry. In 1930 his academic life was brought to an abrupt stop by a severe heat attack. On the advice of his physician he retired from teaching and in 1932 was given the permanent title of Emeritus Professor of Forest Chemistry. Subsequent to his attack, he went to Florida to follow the quiet routine much favored at that time for the treatment of cardiacs. While there he taught small classes in the chemistry department of Rollins College, and during the later period of his recovery he returned to his laboratory at Syracuse for several summers to continue his researches in the mysteries of wood and to help guide and inspire graduate students and colleagues.

His second career in wood chemistry started in 1941 when he joined the staff of The Institute of Paper Chemistry as a Research Associate; here he has continued to teach, research, write, and inspire.

The TAPPI Medal is awarded to those whose achievements "have definitely contributed to the technical progress of the pulp, paper, and paperboard industry." Dr. Wise's contributions have been of many kinds. Several of these I shall review briefly.

First, Louis Wise the teacher. During his years at the New York State College of Forestry and The Institute of Paper Chemistry he has had many of the technical leaders of the pulp and paper industry among his students. For them, the various facets of wood chemistry have been brought to life; his enthusiasm for the subject has been contagious. He made a significant contribution to technical education for our industry by developing at Syracuse a program in wood chemistry and a curriculum in pulp and paper technology and by guiding those programs for almost a decade and one half. Similarly, at The Institute of Paper Chemistry, he has given freely of his time and experience to the evolution of its graduate program and has served this program as a teacher, as a member of its many thesis and problem committees, and as a counselor to staff members and students alike. It would be hard to estimate the number of active TAPPI members who have been under the influence of Dr. Wise's teaching during his 30 years in the field.

The second, Louis Wise the researcher. The second of Dr. Wise's contributions to the pulp and paper industry falls under the category of basic research. His scientific writings based upon his researches have brought him an international reputation. These have carried him extensively into the specific fields of cellulose and hemicelluloses and the relation of these to lignin, nor has he neglected the various so-called extractives of wood. Time will not permit any extended

recital of his specific researches. He has contributed much to our knowledge of the fibrous cell wall. His researches on the hemicelluloses have provided the basis for the elucidation for the nature of these important constituents of wood and pulp. His studies of chlorite holocellulose and the constituents of the polysaccharides in wood and pulp have given tools to the wood analyst. During his earlier years at Syracuse he was much interested in the chemistry of cellulose. Here he compared the nature and properties of celluloses from many species of wood and plant materials giving particular attention to wood cellulose and cotton. He was one of a small band of like-minded chemists who organized the Division of Cellulose Chemistry of the American Chemical Society back in 1922; in 1927–28 he was chairman of that division. In recent years, his researches have leaned somewhat more in the direction of studies on the structure and nature of the hemicelluloses. Altogether, he has published better than 127 papers and books on the subject of wood chemistry, resins, hemicelluloses, and carbohydrates. It was no accident that he was selected as the Honorary Chairman of the very successful Symposium on Hemicelluloses held by the Division of Cellulose Chemistry in the fall of 1959 at Atlantic City.

Louis Wise the bibliographer. A third field, and in some ways the one in which his most important contributions to the pulp and paper industry have been made, might be termed for want of a better word, that of bibliography. I use this term rather loosely to cover such specific items as are indicated by the words abstracter, author, translater, interpreter. If one were to ask a technical librarian where he might find a good discussion on almost any question on wood chemistry, the chances are good he would be told to look in Wise's book on "Wood Chemistry." Actually there are three separate books by Wise on "Wood Chemistry." The first of these volumes appeared in 1926 when L. F. Hawley of the Forestry Products Laboratory and our medalist published an American Chemical Society Monograph on the "Chemistry of Wood." This was followed in 1944 by another American Chemical Society Monograph, this time on "Wood Chemistry" with Wise as the editor and part author. So popular was this that it was followed in 1952 by two volumes of a second edition, this time with Wise and Jahn as editors. These books have been used as texts and reference books all over the world. They have served to provide an effective understanding of the chemistry of the various wood components for students and technical workers in all of the wood utilizing industries.

In addition to these, however, our medalist has contributed, as a conservative figure, hundreds of abstracts appearing first in *Chemical Abstracts* and in later years in the Abstract Bulletin of The Institute of Paper Chemistry. His initials, L. E. W., under an abstract guarantees that the abstract will provide an accurate condensation of the original scientific paper.

Not the least important of his contributions under the general heading of bibliography have been the many articles he has written for the *Paper Industry*, the *American Forest*, and other similar publications in which he has interpreted for the general reader the complex scientific information developed by the specialists. In 1933 in the *American Forest* he described what he called "The Great Lignin Mystery." In 1935 he wrote in the same publication on "Drugs from the Forests." Later he prepared for the American Forestry Association a 28-page monograph entitled "Chemical Treasures of the Forest." In 1943 we find him writing in the pages of the *Paper Industry* about "Sabotage in the Sulfite Cook."

I can think of no better way to end my presentation of Louis Elsberg Wise than to quote the inscription on the testimonial scroll presented to him on the occasion of his 60th birthday and signed by many of his former students at the New York State College of Forestry.

In Honor of His Sixtieth Year
Louis Elsberg Wise

"Your lasting guidance through our lives is a debt that we, your students, deeply appreciate. Your inspiration, contagious enthusiasm, and high professional ethics have molded us during our formative years and continue to serve as a guiding beacon. We salute you as a great Teacher and Scientist, and as a kind and noble Person. In recognition of your gifts of inspiring Teaching, of indefatigable zeal in Research, and of warm human Friendship, we, your former students of The New York State College of Forestry and of Syracuse University, present this Scroll."

This is our 1960 TAPPI medalist; this is Louis Elsberg Wise. And now, Dr. Wise, it is with great pleasure that I present to you, in the name of the Executive Committee of TAPPI, the 1960 TAPPI Medal and its accompanying testimonial.

Acceptance by Louis E. Wise

Mr. Chairman; Dr. Lewis, fellow members of TAPPI:

First of all, let me thank you for this unexpected honor. Phil Nethercut wrote me, very diplomatically, that talks of this type (acceptance speeches) were usually nontechnical, and that they should be reasonably brief. So you will forgive me, I hope, if this talk is a rather personal one. When reminiscences creep in, please bear with me, for they will deal with the educational journeys of your speaker. Let us hope that they will be free from evidences of egocentricity or of "anecdotage."

Certain area of wood chemistry have, as you know, fascinated me, and we will admit that in our industry, wood is an important raw material. Thus over the years, studies have been made on wood cellulose, various wood extractives, and especially on the hemicelluloses, and their bearing on certain pulp properties.

But now comes an admission—or rather a confession. Despite this keen interest in the chemistry of wood, I have really been far more interested in other fibrous raw materials, which in certain of their aspects, are of even greater importance to the pulp and paper industry than is wood. These are *not* of plant origin. Their fiber is *not* cellulosic. I refer to the men who enter industry and who in many instances, have made, and are making outstanding contributions to industrial development. At least one of these was my teacher, and many of them were my students and are my colleagues. And if I merit any recognition whatsoever, in justice, this should be shared with them. So the accolade given me by Harry Lewis, should go to scores of others as well. Thus I must express my gratitude not only to the Executive Committee of TAPPI for this award, but to a group of men and women, who could never be listed completely, but whose importance in my own development is memorable.

Despite obvious omissions, I should like to mention a few of these men. Fifty-four years ago, Otto Kress was a youthful instructor at Columbia who tried to teach me the rudiments of analytical chemistry. My early recollections of Otto include his proficiency as an analyst, his ability as a swimmer, and the forceful and colorful language with which he characterized my shortcomings in the laboratory. Many other teachers contributed to the education of your speaker, and often these instructors were not on the academic staff. Fellow students and very often my *own* students taught me a great deal, and usually they were unaware this this had been their function. Teaching can never be static, and every preceptor must himself remain a life-long student; otherwise he becomes obsolescent and useless. Furthermore, in my opinion he must inculcate certain points of view that extend far beyond the narrow confines of the specific subject matter given in his lectures or seminars. He should be an *awakener*—one who awakens his students to their own potentialities. And not infrequently, the students awaken their instructor as well. These are intangibles about which the teacher is never quite certain, but which make teaching a joyful adventure.

Not a few of my former students are here today, and collectively, and often individually, they have contributed far more to industry than has their old professor. And this is as it should be.

It is on their integrity, resourcefulness, creative imagination, and their surprising tensile strength (if I may use that term)—that production, management, research, and development has depended over the years and must depend in the future. It is men like these former students, who have had the vision to further the intelligent use of the products of photosynthesis—which sustain our industry. It is they who have realized the importance of conservation and of more effective utilization. Through them the growth of our plant fibrous raw materials—barring terrestial or military disasters—should continue for centuries to come. So much for a kudos to the students.

Often the stimulus and the guidance of my many colleagues have proved invaluable. Of these Harry Lewis is one who has often served as a catalyst not only in my own work, but nationally and internationally as well. No one man in the field of chemical education deserves higher praise than does he—and this catalysis is still going on at top speed.

There are many others that deserve mention, but I will only speak of two. One is C. Earl Libby, whose brilliant teaching and remarkable personnel work at Syracuse and at Raleigh have been of enormous help to industry. Another—associated for 6 good years with Earl and myself—was the ever-enthusiastic Harry Weston, whose work for the Paper Industry Management Association all of you will recognize. The founding of the Cellulose Division of the American Chemical Society also proved an education in itself. This came in 1922. We had a small but lively membership—and often we would gather informally (not at the annual meetings, but at suitable intervals) to discuss various aspects of cellulose and wood chemistry. Among the participants—now all belonging to the ages—were Bjarne Johnsen (of the Hammermill Paper Co.), Harry Lebaron Gray (of Eastman Kodak), Lee Hawley of the Forest Products Laboratory, Gustavus Esselen, an eminent consultant, and Professor Harold Hibbert, then at Yale. Your elderly speaker was the youngster in this group—and these informal seminars, often lasting many hours, taught him a great deal.

Well over 30 years ago, it was my privilege to visit certain laboratories in Europe. These, too, have left their impression. On sabbatical leave from the New York State College of Forestry at Syracuse, I met some of the men who were making history in the cellulose and in related fields. There was C. F. Cross of the Cross and Bevan Laboratories at Lincolns Inn above the Law Courts in London. He was the Dean of cellulose chemists for the British Empire at the time. Then I visited Professor Chas Dorée, who was doing work on lignin. Early in August, 1926, came the British Association Meeting at Oxford, where Professor W. N. Haworth of Birmingham, Professor Robert Robinson of Manchester, Dr. Lowry of Cambridge—whose knowledge of medieval architecture vied with their knowledge of the physical sciences. They took me on a long bus ride one afternoon to a lovely Abbey. In Paris, I re-entered the laboratory, this time at the Pasteur Institute, after registering at the Sorbonne under the tutelage of Professor Gabriel Bertrand—working on straw lignin. This laboratory was as cosmopolitan as Paris herself. French students rubbed shoulders with Chinese, Japanese, Americans, Roumanians, Czechs, Poles, Canadians, Englishmen, Swiss, Serbs, and Palestinians. This was an unusual experience in establishing international good will. There I spent 6 months—and these were invaluable. I wish there were time to relate my experience with a remarkable Japanese biochemist and also with a Serbian major, who used me as an experimental animal in studying tear gases.

Another point of great historical interest was the Conservatoire des Arts et Metiers in Paris—where, early in the 19th Century, Professor Anselme Payen first isolated *cellulose* from various plant tissues. Another important visit was that to the Ecole de Papeterie at the University at Grenoble, with its fine staff and magnificent site—in full view of the French Alps.

Later Germany was visited—and in Berlin, I met Professor Hans Pringsheim, Dr. Kurt Hess, and Professor R. O. Herzog—all eminent in the research on cellulose. Subsequently, at the Forest School at Eberswalde, old Dr. Carl Schwalbe regaled me with his lifelong researches on pulp and papermaking. And finally there was a trip to the Friedrichs Polytechnikum in Coethen—where the late Professor Bruno Possaner von Ehrenthal was in charge of a modern school of papermaking, sponsored by the German Paper Manufacturers Association—who had donated nearly all of the equipment.

By this time you may be asking yourselves—"Why is he giving us this travelogue?" Well—the tour furnished a deeper understanding of other men, interested in areas related to my own. But a more important by-product of the journey was a feeling of brotherhood with men of many races, and with many different points of view, often differing sharply from my own. So it served to efface insularity and many prejudgments, and it was an important experience in international relations.

The thought-provoking presidential address given by Dr. Ward Harrison last year, reflected some of these same ideas. I was not in the audience when his speech was given—but on reading it I felt a thrill and an added pride in being a member of TAPPI.

You may recall that Dr. Harrison dealt in part with individual and corporate members of TAPPI—other than those

in North America. The proportion of this membership is surprisingly high, and in Europe, after preliminary skirmishes, many of these members have drawn together. They have met in groups at Grenoble, London, Graz, and in Turin. Within the past few years these meetings have made great progress, and have widened in cooperation and in the exchange of ideas.

Understandably and rightly, the Executive Committee of TAPPI moves slowly in these matters. There can be no wish to organize members in foreign countries into sections of TAPPI that might conflict with or take over pre-existing organizations of other nations, and meetings of the type mentioned must come spontaneously and without external pressures. Now, however, we have a flourishing section of TAPPI in Italy and others may well follow.

In closing I should like to quote from Dr. Harrison's speech —just one sentence which I hope represents the spirit of TAPPI and with your speaker is in sympathetic agreement.

"We have every reason to believe that this same spirit of cooperation will be effective on an international scale in raising the standards of the paper industry everywhere and in building bridges of good will between men and between nations."

This seems to me the vital and intelligent approach. Ideally it should obtain in what we now term the Free World —and very gradually—with luck—we hope it will extend to all countries of our small and troubled planet.

Errata

In the article, "The Present and Future of Gummed Papers," by H. R. Schwappach which appears in the December, 1959, issue of *Tappi* (42, No. 12). In the very first paragraph on page 44A, line 3 reads "and amounting to a total annual sales of $200 million." This should read, ". . . sales of $100 million."

In the January, 1960, issue of *Tappi*, page 98A, under Personal Mention, it is indicated that R. G. Minarik is a consulting engineer for Kimberly-Clark Corp. Mr. Minarik has advised the Association that he does not have an exclusive contract with Kimberly-Clark and that he is generally available on a contract or per diem basis.

Joint Textbook Committee

The accompanying report of textbook sales and financial statement for 1959, of the Joint Textbook Committee of the Paper Industry, indicates that the Committee, sponsoring the publication of the four volume texts "Pulp and Paper Manufacture," had another successful year.

A total of 2817 volumes were sold during 1959 compared to sales of 2728 volumes in 1958.

The financial assets as at Dec. 31, 1959, rose to a new high figure of $20,447.64 with no outstanding or unpaid accounts. Assets increased by a total of $3540.83 during the year. Income is derived from royalties, which amounted to $3213.66, and from bank interest which amounted to $666.55 in 1959. Assets are accumulated by the Committee to pay the cost of future revisions which might be decided upon from time to time.

At the 1959 Annual Meeting of the Committee, R. S. Hatch, who had been a member of the Committee since 1922, tendered his resignation. This was accepted with regret and subsequently, during the year, Foster P. Doane, Jr., was appointed to the Committee to replace Mr. Hatch.

On behalf of the Committee, we herewith express thanks to all those who have assisted the Committee, and special thanks are extended to the publishers, McGraw-Hill Book Co. Inc., and to the editor, J. Newell Stephenson.

Textbook Sales

Sales during 1959 increased over 1958 sales. The sale of 2817 volumes during the year results in a total sale of 39,357 volumes of the fourth edition since the publication of revised volume I in 1950. Details of textbook sales in 1959 are given below:

First three editions→			Total all volumes 51, 356	
	1959 Sales		*Total Sales*	
Fourth edition				
Volume I	736		12,163	
Volume II	528		9,404	
Volume III	605		8,657	
Volume IV	316		5,209	
Total	2185		35,433	
4-volume library sets	632	(158 Sets)	3,924	(981 Sets)
Total	2817		39,357	
Grand total, all editions				90,713

Respectfully submitted,
DOUGLAS JONES, *Secretary-Treasurer*

Financial Statement 1959

Cash on hand Jan. 1, 1959			$16,906.81
Income:			
Royalties	$3,213.66		
Bank interest	666.55		3,880.21
Expenditures:			
Editor's consulting fee	300.00		
New letterheads	39.38	$339.38	
Cash on hand, Jan. 1, 1960			
The Hanover Bank	893.00		
The Bowery Savings Bank	9,766.75		
The Manhattan Savings Bank	9,862.89		
	20,522.64		
Outstanding check No. 688	75.00	20,447.64	
Total Assets Jan. 1, 1960		$20,787.02	$20,787.02

Eleventh

Coating Conference

of the

Technical Association

of the

Pulp and Paper Industry

Edgewater Beach Hotel

Chicago, Ill.

May 23–25, 1960

ASSOCIATION REVIEW—1959

The following report prepared by the Assistant to the President gives the highlights concerning the activities of the Technical Association of the Pulp and Paper Industry in 1959.

Membership

There were 1000 individual members elected in 1959: 585 members resigned or were dropped from the membership. On Dec. 31, 1959, the total individual membership was 9624.

There were nine corporate members elected in 1959. The membership of 19 corporate members was terminated. The corporate membership on Dec. 31, 1959, was 268.

The following companies became corporate members in 1959:

Bharat Carbon & Ribbon Mfg. Co. Ltd., The, New Delhi, India
Ceratonia S. A., Barcelona, Spain
Centre Technique due Papier, Paris, France
Industrie Chimiche Barzaghi Ufa, Milano, Italy
La Cellulose D'Aquitaine (Haute-Garonne), France
National Rayon Corp. Ltd., Mohone-Kalyan, Bombay State, India
Northwestern Corrugated Box Co., Minneapolis, Minn.
Papeteries Steinbach & Cie, Malmedy, Belgium

There were 17 sustaining members elected in 1959; 22 sustaining members resigned. The sustaining membership on Dec. 31, 1959, was 262.

The following companies became sustaining members in 1959:

American-Marietta Co., Newark, Ohio
American Potash & Chemical Co., Los Angeles, Calif.
Balemaster Div., E. Chicago Machine Tool Corp., East Chicago, Ind.
Champlain Co., Inc., Roseland, N. J.
Dixon Chemical & Research, Inc., Bloomfield, N. J.
Eimco Corp., The, Salt Lake City, Utah
Elliot Bros. (London) Ltd., London, England
Gebr. Bellmer, Maschinenfabrik KG, Niefern/Baden, Germany
Instron Engineering Corp., Canton, Mass.
Kamyr, Inc., Hudson Falls, N. Y.
Kellogg, M. W. Co., New York, N. Y.
James Laing, Son & Co. Ltd., Manchester, England
Liberty Engineering Co., Beloit, Wis.
Ralston Purina Co., St. Louis, Mo.
Milton Roy Co., Philadelphia, Pa.
Taylor-Wharton Co. (Div. Harsco Corp.), New York, N. Y.
Testing Machines, Inc., Mineola, L. I., N. Y.
Tragacanth Importing Corp. (TIC), New York, N. Y.

Necrology

The association lost the following members through death in 1959:

Emil H. Anderson, American Shear Knive Co., Homestead, Pa.
Thomas W. Bauer, Abitibi Power & Paper Co., Ltd., Sault Ste. Marie, Ont.
Robert J. Becker, Riegel Paper Co., New York, N. Y.
Truns Biornstad, The Kellner-Partington Paper Pulp Co., Ltd., Hallein, Austria
Asbjorn Borgesen, A/S Narvesens Litteratur Tjeneste, Oslo, Sweden
Erik Bywall, Kvarnsvedens Papiertbruk, Kvarnsvedens, Sweden
John B. Calkin, Calkin & Bayley, Inc., New York, N. Y.
John W. Church, Building Products Ltd., Montreal, Que., Canada
George Cruickshank, National Aluminate Corp., Chicago, Ill.
Lewis Davis, Davis & Bennett, Inc., Worcester, Mass.
Myrl N. Davis, Kimberly-Clark Corp., Neenah, Wis.
Albert G. Durgin, Pulp & Paper Foundation, University of Maine, Orono, Me.
Clarence L. Durkee, Medura Corp., Wausau, Wis.
Frank W. Egan, Frank W. Egan & Co., Somerville, N. J.
John K. Ferguson, St. Regis Paper Co., New York, N. Y.
Karl Finckh, Metalltuch and Maschinenfabrik Werk, Reutlingen, Wurtt., W. Germany
Harry C. Fisher, The Gardner Board & Carton Co., Lockland, Ohio
Gordon I. Hoover, Provincial Paper Ltd., Thorold, Ont., Canada
Allan Hyer, Pusey and Jones Corp., Wilmington, Del.
William T. Kirby, Crane & Co., Dalton, Mass.
Ralph M. Kingsbury, Forest Products Laboratory, Madison, Wis.
Francis I. Kittredge, General Electric Co., Philadelphia, Pa.
Otis H. Knapp, New York & Pennsylvania Co., Johnsonburg, Pa.
Ralph A. Masten, Southern Kraft Div., International Paper Co., York Haven, Pa.
Julian M. Maxson, Maxson Automatic Machinery Co., Westerly, R. I.
H. W. Meijer, O. J. Meijer's Dextrinefabrieken, N.V., Veendam, Holland
A. D. Merrill, Chemipulp Process, Inc., Watertown, N. Y.
William H. Millspaugh, Millspaugh Ltd., Tinsley, Sheffield, England
Lorne B. Mulloy, Haloid Xerox, Inc., Rochester, N. Y.
L. C. Oseland, Carpenter Steel Co., Kenilworth, Ill.
Cecil C. Parvin, Nekoosa-Edwards Paper Co., Port Edwards, Wis.
Haskell J. Peddicord, Procter & Gamble Co., Cincinnati, Ohio
John J. Priest, Halifax Paper Co., Inc., Roanoke Rapids, N. C.
L. G. Neubauer, Tasman Pulp and Paper Co. Ltd., Kawerau, New Zealand
Robert D. Rusch, Chase Bag Co., Chagrin Falls, Ohio
Carl A. Sholderbrand, Spaulding Pulp & Paper Co., Newberg, Ore.
Charles J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y.
Leonard Smidth, American Viscose Co., Marcus Hook, Pa.
Ray F. Stafford, Southern California Minerals Co., Los Angeles, Calif.
Edward J. Sullivan, Bowater Paper Co., Inc., New York, N. Y.
Clifford R. Swett, National Wax Co., Skokie, Ill.
George Thomson, Fabric Research Laboratories, Inc., Dedham, Mass.
Charles H. Waldhauer, U. S. Playing Card Co., Cincinnati, Ohio
J. G. Weeldenburg, Algemene Kunstzijde Unie N.V., Arnheim, Holland
George L. Witham, Orr Felt & Blanket Co., Piqua, Ohio

Publications of the Association

Tappi

Tappi, the monthly magazine of the association, completed its eleventh year of publication. In 1959 there were 1016 pages published in the technical section. This compared with 816 pages in 1958 and 994 pages in 1957. The total number of pages published was 3296 in contrast to 3398 in 1958. The circulation of the magazine made a substantial increase. There were 1065 pages of advertising run in 1959 in contrast to 1096 pages in 1958.

Bibliography of Papermaking and U. S. Patents

One cloth-bound issue of The Bibliography of Papermaking was issued in 1959. It was prepared by Jack Weiner and his associates at The Institute of Paper Chemistry.

College Textbook

During the year a two-volume, loose-leaf College Text-

book of Pulp and Paper Manufacture was published by The Association under the direction of its Training and Education Committee. This effort was initiated by the heads of the pulp and paper courses in a number of colleges. It was written primarily for use in college courses in pulp and paper technology. In its present form it is subject to constant review in preparation for future editions.

Monographs

No monographs were issued in 1959. Four monographs are in preparation and should be ready for publication in 1960.

Special Reports

One Special Report was issued in 1959:

No. 427. Groundwood Wet Web Strength

Standards, Suggested Methods, and Data Sheets

No Standards, Suggested Methods, nor Data Sheets were issued in loose-leaf form in 1959, although several were published in preliminary form in *Tappi*.

TAPPI Medal Award

The 27th TAPPI Medal for outstanding contributions to the technical development of the pulp and paper industry was awarded to Karl O. Elderkin, president of Bowaters Research & Development Inc., Calhoun, Tenn. The presentation was made by Gunnar W. E. Nicholson, president of Tennessee River Paper Mills, New York, N. Y.

Employment

The shortage of technically trained men in the pulp and paper industry both for the present and foreseeable future has been evidenced by the large number of positions open advertisements that have appeared in *Tappi* and other publications. The Association has endeavored to help in this situation by offering special services at its annual meeting and by arranging to have speakers attend a large number of student professional society meetings in various colleges throughout the country. At the end of the year the Association issued a 20-page booklet entitled "What You Should Know about Career Opportunities Offered by the Pulp and Paper Industry." This booklet is being used for recruitment purposes.

Headquarters Office

The Association offices were moved, in the fall, from 155 East 44th St. to 360 Lexington Ave., New York, N. Y. The staff was enlarged by the addition of Michael Kouris as an assistant editor and M. A. Burnston as a technical assistant.

Local Sections

Two new sections received their charter in 1959. The Gulf Coast Section ceremonial was held at the Jung Hotel in New Orleans, La., in May and the Italian Section was chartered at Lake Como, Italy, in October.

The chairmen of local sections elected in 1959 were:

Pacific—Norval Magnusson, Puget Sound Pulp & Timber Co., Bellingham, Wash.
Gonden Gate District—John Hartsock, International Paper Co., Container Div., San Jose, Calif.
Lake States—Robert Leaf, Jr., Shawano Paper Mills, Shawano, Wis.
Delaware Valley—George K. Boger, Jr., Amalgamated Chemical Co., Philadelphia, Pa.
Kalamazoo Valley—William O. Kroeschell, Michigan Carton Co., Battle Creek, Mich.
New England—John Lewis, Pulp and Paper Research Centre, Lawrence, Mass.
Eastern District (N. E.)—Roger N. Wiewel, Pulp Div., Weyerhaeuser Timber Co., Clinton, Mass.
Ohio—Virgil E. Perry, Harding-Jones Paper Co., Middletown, Ohio

Technical Association of the Pulp and Paper Industry
Statement of Income and Expenses—1959

	Budget 1959	*Actual 1959*
Income		
Members Dues	$300,000.00	$302,159.62
Conference Registration Fees	89,000.00	100,741.50
Publications: (*Tappi* and others)	$295,500.00	$317,501.40
Income from Investments	37,000.00	38,973.90
	$721,500.00	$759,376.42
Expenses		
General Administration	$144,764.00	$181,433.66
Divisions and Committees	202,326.00	211,601.09
Local Sections	21,890.00	18,571.98
Publications	327,130.00	281,541.66
Loss on Sale of Investments	...	3,040.18
	$696,110.00	$696,188.57
Excess of income over expenses for the year ending Dec. 31, 1959	$ 25,390.00	$ 63,187.85

Indiana District—Charles E. Eberly, Paper Art Co., Inc., Indianapolis, Ind.
Empire State—F. W. O'Neil, College of Forestry, State University of New York, Syracuse, N. Y.
Metropolitan District (E. S.)—Harold L. Peckham, Oxford Paper Co., New York, N. Y.
Northern District (E. S.)—Russell C. Clark, Newton Falls Paper Co., Newton Falls, N. Y.
Central District (E. S.)—Allen F. Holmes, Sealright-Oswego Falls Corp., Fulton, N. Y.
Western District (E. S.)—Edward F. Andrews, International Paper Co., Niagara Falls, N. Y.
Eastern District (E. S.)—Paul Page, Imperial Color & Chemical Corp., Glens Falls, N. Y.
Maine-New Hampshire—Andrew J. Chase, University of Maine, Orono, Me.
Chicago—Henry J. Klauke, Container Corp. of America, Chicago, Ill.
St. Louis District (Chicago)—James R. Lyon, Alton Box Board Co., Alton, Ill.
Lake Erie—John C. Boynton, Fasson Products, Painesville, Ohio
Southeastern—R. R. Chase, Union Bag-Camp Paper Corp., Savannah, Ga.
Gulf Coast—William Elsevier, International Paper Co., Mobile, Ala.
Virginia-Carolina—Ross F. Miller, Continental Can Co., Hopewell, Va.
Italian (Sezione Italiana)—Piero Bersano, Cartiere Burgo, Turin, Italy

Certificates of Appreciation

During the year a practice was initiated whereby chairman of divisions, committees, and local sections were given certificates of appreciation at the time when they retired from such positions. The following division and committee chairman received certificates.

George G. Rumberger—TAPPI-ASTM Technical Committee on Petroleum Wax
William E. Watson—Paperboard Testing Committee
Arthur E. Ewing—Paper and Paperboard Testing Group
J. A. Van den Akker—Optical Properties Committee
William H. Aiken—Industrial Division
C. E. Libby—Training & Education Committee
Jo R. Persons—Engineering Economics Committee
Forrest A. Simmonds—Dissolving Pulp Committee
Richard G. Knechtges—Semichemical Pulping Committee
John R. Curtis—Engineering Division
Nicholas S. Shoumatoff—Fluid Mechanics Committee
Keith Provo—Corrugated Containers Production Committeee
Reginald D. Merrill—Corrugated Containers Engineering Committee
Harris O. Ware—Coating and Graphic Arts Division
Frederic S. Klein—Paper Manufacture Division
Paul K. Wolper—TAPPI-PI Packaging Materials Testing Committee

Alfred D. Bonanno—Coating Committee
Roscoe C. Masterman—Fourdrinier Committee
James J. Forsythe—Deinking Committee
Daniel Patch—Industrial Engineering Committee
Robert L. Jenk—Corrugated Containers Division
J. McK. Limerick—Alkaline Pulping Committee
Earl S. McColley—Chemical Methods Committee

The following retiring chairman of local sections received certificates:

Paul S. Billington—Pacific Section
Walter J. Bublitz—Lake States Section
Donald C. Kane—Delaware Valley Section
Edward E. Stephenson, Jr.—Kalamazoo Valley Section
E. Whitman Strecker—New England Section
E. William Petrich—Ohio Section
J. Wayne Morrow—Empire States Section
Andrew J. Chase—Maine-New Hampshire Section
Melvin W. Snover—Chicago Section
Dennis E. Heindel—Lake Erie Section
J. Edmund Doyle—Gulf Coast Section
Robert E. Bowen—Virginia-Carolina Section

Research Projects

During 1959 the Association made research grants amounting to $57,946. A detailed report of these research projects is included in the report of the Project Appropriations Committee.

Meetings of the Association

In addition to the Annual Meeting the Association held nine functional conferences during 1959. The details concerning these meetings have been published in *Tappi* during the year.

1959 Annual Meeting

The 44th Annual Meeting of the Association was held at the Commodore Hotel, New York, N. Y., on Feb. 23–26, 1959. An attendance of about 2800 were registered and 107 papers were presented at the technical sessions. The annual luncheon was featured by the presentation of the TAPPI Medal to Karl O. Elderkin, president of Bowaters Research & Development Co. The presentation was made by G. W. E. Nicholson, president of the Tennessee River Paper Mills, New York, N. Y. Following the luncheon a joint TAPPI-APPA Research Forum was presented at the Waldorf-Astoria Hotel. The featured speakers were Lt. Gen. James M. Gavin of Arthur D. Little, Inc., Cambridge, Mass., A. B. Layton, president of Crown Zellerbach Corp., San Francisco, Calif., and Howard S. Turner, vice-president of Jones & Laughlin Steel Co., Pittsburgh, Pa.

Tenth Coating Conference

The Tenth Coating Conference was held at the Statler-Hilton Hotel, Boston, Mass., on May 25–27, 1959. There were 801 registrants at the meeting which featured 16 technical papers and panel discussions. F. Kaulakis, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., was conference chairman of the meeting. R. W. Hagemeyer, Wyandotte Chemicals Co., Wyandotte, Mich., was program chairman and R. E. Kilty, A. E. Staley Mfg. Co., Boston, Mass., was chairman of the local arrangements committee. A panel symposium featured the past, present, and future of coatings. Stanton W. Mead, president of the Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., was the luncheon speaker. Plant tours were made of the facilities of Arthur D. Little, Inc., Cambridge, Mass.; Dewey & Almy Chemical Division of W. R. Grace & Co., Cambridge, Mass.; Oxford Paper Co., Lawrence, Mass.; and the Nashua Corp., Nashua, N. H. The meeting was dedicated to the memory of Edwin Sutermeister, formerly of the S. D. Warren Co., Cumberland Mills, Me.

Eighth Statistics Course

The Eighth TAPPI-CPPA Statistics Course was held at Dartmouth College, Hanover, N. H., on July 20–31, 1959. Twenty-one students attended the basic course and 12 students participated in the advanced seminar. The staff of instructors consisted of: Geoffrey Beall, Gillette Safety Razor Co., Boston, Mass.; John Mandell, National Bureau of Standards, Washington, D. C.; F. R. Sheldon, Food Machinery & Chemical Corp., Princeton, N. J.; and R. Wormleighton, University of Toronto, Toronto, Canada.

Tenth Testing Conference

The Tenth Testing Conference was held at the Multnomah Hotel, Portland, Ore., on Aug. 17–21, 1959. There were 178 registrants. There were 18 papers presented as well as a panel discussion on pulp evaluation. The conference chairman was C. S. Walseth, Weyerhaeuser Timber Co., Cosmopolis, Wash.; S. M. Chapman, Pulp and Paper Research Institute, Montreal, Canada, was program chairman; and F. E. Caskey, Morden Machines Co., Portland, Ore., was local arrangements chairman. Prior to the conference mill tours were araanged at the Crown Zellerbach Co. mill in Camas, Wash., and the Weyerhaeuser Timber Co. mill at Longview, Wash. The banquet speaker was Stewart Hollbrook who gave his interesting talk "Daylight in the Swamp." Following the meeting there was a woods trip to the Clatsap tree farm of the Crown Zellerbach Corp. The Testing Conference, as usual, was featured by workshop meetings of committees of the Testing Division.

Fourth Fundamental Research and Interfiber Bonding Conference

A symposium on the fundamentals of fiber attraction and bonding was sponsored jointly by the Fundamental Research Committee and the Wet Strength and Interfiber Bonding Committee at The Institute of Paper Chemistry, Appleton, Wis., on Sept. 9–11, 1959. There were about 200 registrants. Fourteen papers were presented. Sessions dealt with "Principles of Adhesion," Roy P. Whitney, The Institute of Paper Chemistry, chairman; "Development of Wet Strength," J. J. Shipman, Kimberly-Clark Corp., Neenah, Wis., chairman; "Fiber Properties Affecting Adhesion," G. K. Dickerman, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., chairman; "Development of Bonds," R. A. A. Hentschel, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., chairman; "Role of Additives in Bonding," K. W. Britt, Scott Paper Co., Chester, Pa., chairman. John Strange, president of The Institute of Paper Chemistry, was the luncheon speaker.

Ninth Corrugated Containers Conference

The Ninth Corrugated Containers Conference was held at the Jung Hotel, New Orleans, La., on Sept. 15–17, 1959. There were 353 registrants. J. H. Rooney, Robert Gair Products Group, Continental Can Co., New Orleans, La., was conference chairman. H. R. Crais of the Continental Can Co. was local arrangements chairman. Two technical sessions were held: "Engineering Advances Contributing to the Reduction of Scrap," R. C. Hutcheson, Union Bag-Camp Paper Corp., chairman; and "What Is Required in Corrugated Board to Compete with the Demands of Modern Packaging," G. R. Wilmer, American Box Board Co., Grand Rapids, Mich., chairman. A mill tour was made through the plant of the Gaylord Container Division of Crown Zellerbach Corp.

Fourteenth Plastics-Paper Conference

The Fourteenth Plastics-Paper Conference was held at the Edgewater Beach Hotel, Chicago, Ill., on Sept. 20–23, 1959. There were 467 registrants. W. L. Hardy, International Minerals and Chemical Co., Skokie, Ill., was conference chairman. G. H. Sullivan, H. P. Smith Paper Co., Chicago, Ill., was program chairman, and W. R. Price, Central Waxed

Paper Co., Chicago, Ill., was local arrangements chairman. Twenty-five papers were presented in six sessions. A feature of the program was a session devoted to the Food and Drug Administrations Rulings and Obligations of Industry. At the banquet the principal speaker was L. K. Hanson, vice-president (Overseas Division), Continental Can Co., New York N. Y., whose subject was "What Goes Over Overseas."

Fourth Deinking Conference

The Fourth Deinking Conference was held at the Roger Smith Hotel, Holyoke, Mass., on Oct. 8–9, 1959. There were 127 registrants. J. W. Wendell, Jr., Tileston & Hollingsworth Co., Hyde Park, Mass., was conference chairman, and H. E. Corwin, Diamond Gardner Corp., Palmer, Mass., was program chairman. Two sessions were held at which eight papers were presented. W. D. Boggess, Beveridge Paper Co., Indianapolis, Ind., presided as toastmaster at the banquet. John Moriarty of Arthur D. Little, Inc., Cambridge, Mass., gave a talk on "The Role of Flavor in Food Acceptance." Each afternoon was devoted to mill visits. The visit on Thursday was made to the Erving Paper Mills, Erving, Mass., and on Friday to Crocker, Burbank & Co., Fitchburg, Mass.

Fourteenth Engineering Conference

The Fourteenth Engineering Conference was held at the Penn Sheraton Hotel, Pittsburgh, Pa., on Oct. 12–15, 1959. There were 712 registrants. The conference was sponsored by the Engineering Division with John R. Curtis of The Scott Paper Co. serving as general chairman. M. H. Fisher of Westinghouse Electric Corp., East Pittsburgh, Pa., was local arrangements chairman. More than 50 papers were presented in 17 sessions and panel meetings. The speaker at the banquet was Countess Maria Pulaski ("My Life as a Spy"), and the speaker at the division luncheon was J. R. Curtis of the Scott Paper Co. whose subject was "The Challenge to Engineers in the Paper Industry." Visits were made to the plants of the Jessop Steel Co., National Annealing Box Co., both of Washington, Pa., Westinghouse Test Nuclear Reactor Site, Waltz Mills, Pa., and the Westinghouse Research Laboratory, Pittsburgh, Pa.

Thirteenth Alkaline Pulping Conference

The Thirteenth Alkaline Pulping Conference was held at the Robert Meyer Hotel, Jacksonville, Fla., on Nov. 4–6, 1959. There were 522 registrants. J. McK. Limerick of Bathurst Power & Paper Co., St. Laurent, P. Q., Canada, was general chairman. K. D. Running of the Halifax Paper Co., Roanoke Rapids, N. C., was program chairman for the alkaline pulping sessions and R. E. Collins of the Crossett Co., Crossett, Ark., was program chairman for the semi-chemical pulping sessions. S. P. Kaptain was the conference arrangements chairman. Twelve papers were presented in the alkaline pulping session and five papers in the semi-chemical pulping session. The speaker at the luncheon was Haydon Burns, Mayor of Jacksonville, who presented "The Jacksonville Story." Visits were made to the mill of the St. Regis Paper Co. in Jacksonville and to Engineering Experiment Station of the University of Florida at Gainesville, Fla.

Divisions and Committees

During 1959 the following changes were made in the division and committee structures.

The Industrial Division was abolished, and its committees reassigned to existing divisions as follows: the Agricultural Fibers Committee was placed in the Pulp Manufacture Division; the Structural Fibrous Materials Committee and the Water Committee joined the Paper and Board Manufacture Division, and the Training and Education Committee was assigned to the Research and Development Division. The former Paper Manufacture Division was re-named the Paper and Board Manufacture Division.

The following changes in division and committee officers were made.

Coating and Graphic Arts Division. R. T. Trelfa, Perkins-Goodwin Co., New York, N. Y., replaced H. O. Ware, Beveridge Paper Co., Indianapolis, Ind., as division chairman, and C. A. Morton, Kimberly-Clark Corp., Chicago, Ill., replaced Mr. Trelfa as division secretary. In the Coating Committee, J. T. Loomer, Continental Can Co., New York, N. Y., succeeded A. D. Bonnano, Kelco Co., New York, N. Y., as committee chairman. J. E. Wilber, St. Regis Paper Co., Deferiet, N. Y., succeeded Mr. Loomer as committee vice-chairman, and C. G. Landes, Wica Chemical Co., Charlotte, N. C., succeeded Mr. Wilber as committee secretary. In the Graphic Arts Committee, J. H. Wing, Continental Can Co., Uncasville, Conn., succeeded J. M. Fetsko, Lehigh University, Bethlehem, Pa., as program officer, Miss Fetsko replaced T. E. Irwin, Oxford Paper Co., Chicago, Ill., as public relations officer, and M. C. Rogers, Chicago Paper Testing Lab., Chicago, Ill., became committee secretary.

Converting and Consuming Division. J. C. Pullman, American Cyanamid Co., New York, N. Y., became vice-chairman of the division, and V. T. Stannett, New York State University, College of Forestry, became division secretary. In the Plastics Committee, R. W. Loheed, Chas. T. Main, Inc., Boston, Mass., replaced C. J. Seiler, Behr-Manning Co., Troy, N. Y., as committee vice-chairman, and R. E. Benton, Goodyear Tire & Rubber Co., Akron, Ohio, succeeded H. Spector, Premoid Corp., W. Springfield, Mass., as committee secretary.

Paper and Board Manufacture Division. R. C. Masterman, International Paper Co., Glens Falls, N. Y., replaced F. S. Klein, Byron Weston Co., Dalton, Mass., as division chairman. In the Cylinder Board Committee, C. D. Coffman, The Chesapeake Paperboard Co., Baltimore, Md., replaced W. R. Csellak, The Gardner Board & Carton Co., Middletown, Ohio, as committee vice-chairman. In the Fourdriner Committee, W. H. Kennedy, Black Clawson Co., Watertown, N. Y., succeeded R. C. Masterman as committee chairman, R. W. Peters, Eastman Kodak Co., Rochester, N. Y., replaced Mr. Kennedy as committee vice-chairman, and R. W. Hisey, S. D. Warren Co., Cumberland Mills, Maine, succeeded Mr. Peters as committee secretary. In the Water Committee, J. G. Patrick, West Virginia Pulp & Paper Co., Luke, Md., succeeded J. S. G. Shotwell consultant, New York, N. Y., as committee chairman.

Research and Development Division. In the Forest Biology Committee, D. D. Stevenson, The Buckeye Cellulose Corp., Foley, Fla., replaced P. N. Joranson, The Institute of Paper Chemistry, Appleton, Wis., as committee chairman, R. J. Seidl, Simpson Timber Co., Seattle, Wash., replaced B. Zobel, N. C. State College, School of Forestry, Raleigh, N. C., as vice-chairman, and J. W. Jonnson, Union Bag-Camp Paper Corp., Savannah, Ga., replaced P. C. Wakeley, U. S. Dept. of Agriculture, New Orleans, La., as secretary. In the Microbiological Committee, R. F. Drescher, Buckman Laboratories, Memphis, Tenn., succeeded A. N. Stern, West Virginia Pulp & Paper Co., Covington, Va., as committee secretary. In the Training and Education Committee, L. C. Jenness, University of Maine, Oron, Me., succeeded C. E. Libby, N. C. State College of Agriculture & Engineering, Raleigh, N. C., as committee chairman, and J. Lewis, Pulp & Paper Res. Center, Lawrence, Mass., became committee vice-chairman.

Testing Division. In the Chemical Methods Committee, W. K. Wilson, National Bureau of Standards, Washington, D. C., succeeded E. S. McColley as committee chairman. In the Optical Properties Committee, R. S. Hunter, Hunter Associates Lab., McLean, Va., succeeded J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis.,

as committee chairman, and W. G. Vincent, Strathmore Paper Co., W. Springfield, Mass., replaced Mr. Hunter as vice-chairman. On the Routine Control Methods Committee, L. J. Slentz, Allied Chemical & Dye Corp., Solvay, N. Y., was named vice-chairman. On the Wax Testing Committee, M. W. Kane, The KVP Co., Parchment, Mich., succeeded G. G. Rumberger, Sutherland Paper Co., Kalamazoo, Mich., as committee chairman and D. I. Walker, Standard Oil Co., Chicago, Ill., replaced W. J. Yates, Shell Oil Co., New York, N. Y., as secretary. In the Pulp Testing Committee, J. C. Cousins, Penobscot Chemical Fibre Co., Great Works, Me., succeeded H. A. Smith as committee chairman, and C. S. Walseth, Weyerhaeuser Timber Co., Cosmopolis, Wash., became vice-chairman. W. H. Aiken, Personal Products Corp., Milltown, N. J., succeeded A. R. Ewing, Bemis Bro. Bag Co., Boston, Mass., as chairman of the Paper and Paperboard Group. In the Packaging Materials Testing Committee, C. M. Woodcock, General Foods Corp., Battle Creek, Mich., succeeded P. K. Wolper as committee chairman, and K. W. Ninneman, Olin Mathieson Chemical Corp., New Haven, Conn., replaced Mr. Woodcock as committee secretary. In the Paperboard Testing Committee, W. C. Utschig, General Foods, Inc., Battle Creek, Mich., succeeded W. E. Watson, New Haven Board & Carton Co., New Haven, Conn., as committee chairman, W. O. Kroeschell, Michigan Carton Co., Battle Creek, Mich., replaced Mr. Utschig as vice-chairman, and D. E. Marth, Morris Paper Mills, Morris, Ill., succeeded Mr. Kroeschell as secretary.

Corrugated Containers Division. B. Mendlin, Cornell Paperboard Products Corp., Milwaukee, Wis., succeeded R. L. Jenk, Mead Containers, Inc., Cincinnati, Ohio, as division chairman. J. J. Koenig, Gaylord Container Corp., Div. of Crown Zellerbach Corp., St. Louis, Mo., replaced Mr. Mendlin as vice-chairman. In the Raw Materials Committee, G. R. Wilcox, American Box Board Co., Grand Rapids, Mich., succeeded D. C. Shepard, Jr., Menasha Wooden Ware Corp., Menasha, Wis., as chairman. A. L. Magunson, Potlatch Forest Products, Chicago, Ill., replaced M. Block, Stone Container Corp., Chicago, Ill., as vice-chairman. B. R. Gibson, Jr., St. Joe Paper Co., Port St. Joe, Fla., replaced Mr. Wilmer as secretary.

In the Industrial Engineering Committee, T. W. Carroll, Owens-Illinois Glass Co., Toledo, Ohio, became vice-chairman and R. S. Owen, R. S. Owen Co., Chicago, Ill., became secretary.

Engineering Division. M. J. Osborne, Bowaters Southern Paper Corp., Calhoun, Tenn., succeeded J. R. Curtis, Scott Paper Co., Chester, Pa., as chairman. N. Shoumatoff, West Virginia Pulp and Paper Co., New York, N. Y., replaced Mr. Osborne as vice-chairman. In the Corrosion Committee, H. B. Harris, Jr., Union Bag-Camp Paper Corp., Savannah, Ga., became vice-chairman, and A. O. Caldwell, Service and Erection Co., Pittsburgh, Pa., replaced H. W. Fritts, Aluminum Co., of America, New Kensington, Pa., as secretary.

In the Electrical Engineering Committee, S. A. Andersen, West Virginia Pulp and Paper Co., New York, N. Y., succeeded R. F. Sorenson, St. Regis Paper Co., Jacksonville, Fla., as chairman. E. G. Parrish, Crossett Co., Crossett, Ark., replaced I. M. Witham, Byron Weston Co., Dalton, Mass., as vice-chairman, and H. A. Wright, Allis Chalmers Mfg. Co., West Allis, Wis., succeeded G. E. Shaad, General Electric Co., Schenectady, N. Y., as secretary. In the Fluid Mechanics Committee, C. A. Lee, Formex Co., Knoxville, Tenn., succeeded N. Shoumatoff, West Viginia Pulp & Paper Co., New York, N. Y. as chairman. G. L. Calehuff, West Virginia Pulp & Paper Co., Covington, Va., replaced Mr. Lee as vice-chairman. In the Maintenance Engineering Committee, H. M. Reed, Jr., International Paper Co., Springhill La., succeeded R. Q. Connor, The Crossett Co., Crossett, Ark., as chairman, and W. R. Palmer, Link Belt Co., Shreveport, La., replaced H. K. Kingsbury, Allis Chalmers Mfg. Co., Norwood, Ohio, as secretary.

In the Mechanical Engineering Committee, J. S. Mudgett, Strathmore Paper Co., West Springfield, Mass., succeeded M. N. Davis, Kimberly-Clark Corp., Neenah, Wis. (deceased Dec. 22, 1959), as chairman. In the Steam and Power Committee, H. R. Emery, St. Regis Paper Co., Jacksonville, Fla., succeeded R. V. Knapp, Mosinee Paper Co., Mosinee, Wis., as chairman. C. L. Wills, Halifax Paper Co., Inc., Roanoke, Rapids, N. C., replaced Mr. Emery as vice-chairman.

In the Mechanical Pulping Committee, J. K. Kirkpatrick, Bowaters Southern Paper Corp., Calhoun, Tenn., succeeded A. A. Yankowski, Kimberly-Clark Corp., Neenah, Wis., as committee chairman. S. R. Parsons, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis., replaced Mr. Kirkpatrick as first vice-chairman and M. S. Htoo, International Paper Co., Glens Falls, N. Y., succeeded Mr. Parsons as second vice-chairman.

Project Appropriations Committee

Fewer committee requests were received in 1959 for TAPPI funds to finance their projects than at any time during the past five years. Only nine requests (totaling $62,445.71) were submitted by seven committees to the Project Appropriations Committee, and all requests were granted. Eight of these were to finance continued projects, and one project was new. The Executive Committee allocated $50,000 for project appropriations in its February, 1959, budget, and an additional $12,500 was voted at its September meeting, making a total of $62,500 for aiding committee projects. Attached to this report is a list of the committee requests received and grants made in 1959.

At the annual meeting of the Project Appropriations Committee in February, 1959, it was decided that a preliminary vote on the appropriation requests would be solicited and the results mailed to the members with their comments. Thus, all committee members would benefit from the group thinking before the final decision was made. This plan was followed with the April and October appropriation requests. With the exception of only two requests, the preliminary and final votes were identical.

In accordance with the suggestions made at the annual meeting of the committee, P. E. Nethercut submitted the following reports in a memorandum dated Oct. 26, 1959:

A. Recommendations on Research Policy
B. Research Foundations
C. TAPPI Patent Policy

These three reports were approved by the Executive Committee at its meeting on Sept. 28, 1959. In the report on research policy, among the items mentioned are:

1. Change of name of Research Appropriations Committee to "Project Appropriations Committee."
2. Continued acceptance of the 1957 "Statement of TAPPI Research Policy" [*Tappi* 41, 111A (March, 1958)].
3. Division and Committee Chairmen are advised to exercise better control over projects financed by TAPPI funds. The appointment of Divisional "Project Advisory Committees" and use of policies similar to those in the Engineering Division Policy Manual are urged.
4. The appointment of a Research Advisory Council by the president of TAPPI to define and develop major long range research programs to be supported by industry.

With the conclusion of the 1960 Annual TAPPI Meeting three members retire in accordance with a policy of rotating membership and a three year tenure. The retiring members are K. O. Elderkin, M. S. Kantrowitz, and H. S. Gardner. As their successors, the Executive Committee has appointed C. R. Calkins, K. G. Chesley, and E. O. Ericsson.

Technical Association of the Pulp and Paper Industry
Appropriation Requests Received and Grants Made in 1959

Grant number	*Project*	*Committee*	*Amount*
164	Preparation and Properties of Polymerhomologous Oligosaccharides of the Cellulose Series (renewal)	Wood Chemistry	$ 2,885.
165	Isolation of Dimers from Lignin (renewal). This project was cancelled Sept. 1, 1959. Grant No. 165 was not paid.	Wood Chemistry	4,500.
166	Surface Strength of Paper (renewal)	Graphic Arts	10,000.
167	Smoothness and Compressibility of Paper as Related to Printability (renewal)	Paper & Paperboard Group of the Testing Division	7,000.
168	Transfer and Penetration Aspects of Ink Receptivity (new)	Graphic Arts	12,000.
169	Flow Properties of Paper Coating Colors (renewal)	Coating	5,200.
170	Friction of Paper Stock in Fittings (renewal)	Fluid Mechanics	710.71
171	Study of Air-Leak Smoothness Testers (renewal)	Paper Testing and Paper and Paperboard Group	2,400.
172	Study of the Flow Characteristics of Dilute Fiber Suspensions: Turbulent Transfer Mechanics with Neutrally Buoyant Suspensions (renewal)	Fluid Mechanics	17,750.
		Total funds granted in 1959	$62,445.71
		Less Grant No. 165 (cancelled)	4,500.00
		Total Grants	$57,945.71

Requests 164–170 were given consideration in April, 1959; requests 171–172, in Oct., 1959.

For 1960, the Project Appropriations Committee comprises the following members:

J. R. Lientz (*ex-officio*)
H. M. Annis (*ex-officio*)
W. C. Bloomquist (1960)
R. H. Doughty (1960)
J. D. Lyall (1960)
A. Byfield (1961)
G. Renegar (1961)
J. J. Thomas (1961)
C. R. Calkins (1962)
K. G. Chesley (1962)
E. O. Ericsson (1962)
J. L. Parsons, *Chairman*

J. L. Parsons, *Chairman*
Project Appropriations Committee

PROGRESS REPORTS ON COMMITTEE PROJECTS CURRENTLY FINANCED BY TAPPI GRANTS

Coating and Graphic Arts Division (R. T. Trelfa, General Chairman)

Coating Committee (J. T. Loomer, Chairman): Grants No. 155 ($1435) in 1958, and No. 169 ($5200) in 1959. Flow Properties of Paper Coating Colors. This is to be an analytical study of the relationships between the flow properties of coating colors and such coating properties as penetration characteristics, coat weight and patterning during film splitting. These property relationships appear to be most susceptible to analysis when the coating speed, penetration and film splitting are measured by the roll-inclined plane technique. The apparatus necessary to carry out the experimental program has been acquired and the techniques have been developed. Furthermore, calibration of the instrument has been accomplished and data have been assembled on the relationship between viscosity of a Newtonian fluid (sugar solutions) and film transfer on nonabsorbent and absorbent bases. The other steps in the program are: (1) The relationship between flow properties on non-Newtonian fluids (starch suspensions) and film transfer on nonabsorbent and absorbent bases; (2) The relationship between flow properties of clay suspensions in Newtonian fluids of different viscosities and film transfer on nonabsorbent and absorbent bases; and (3) The relationship between flow properties of clay suspensions in non-Newtonian fluids (starch suspensions) and film transfer on nonabsorbent and absorbent bases.

This study is being carried out at the University of Maine. As of Oct. 16, 1959, the balance of the appropriation unspent was $3645.04.

Graphic Arts Committee (C. A. Morton, Chairman): Grants No. 130 ($10,000) in 1957 and No. 166 ($10,000) in 1959. Surface Strength of Paper. A summary of the first year's work, financed by Grant No. 130 plus $4060 from the Lehigh University Printability Research Fund, was presented as a technical paper at the 1959 Annual Meeting of TAPPI. The project has been continued with Grant No. 166. The objective is a definition of a standard method or methods for measuring the pick resistance of paper and paperboard. The status of the program is given in the following quotation from the forthcoming progress report:

"It was generally agreed that the original plan would have to be altered to include investigation of the causes of the variability so that the sources might be eliminated.

"Secondly, a review of the first year's results led to the conclusion that the accelerating speed instruments offer the best hope of fulfilling the goal of the project. Their speed of operation gives them a major advantage in quality control over all other types of pick testers studied. In addition, they are capable of rating paper with and against the machine direction; some pick measuring cannot do this.

"The agenda for the second year of work at Lehigh therefore includes a study of the operational variables of the two available accelerating speed instruments: the IGT and the FOGRA. A recommended procedure which thus evolves is to be used for testing 100 paper and paperboard samples along with the traditional Dennison Wax Pick Test. Extensive production press tests are also a major part of the agenda.

"The progress report is divided into four parts:

I. Interim Work by Cooperating Laboratories
II. Production Press Tests
III. Rheological Measurements on the IPI Tack Graded Inks
IV. Reproducibility Studies with the IGT Pick Tester."

Total expenses to Jan. 15, 1960, amount to $6570, leaving a balance of $3430.

Grant No. 168 ($12,000) in 1959. Transfer and Penetration Aspects of Ink Receptivity. This project was initiated at Lehigh University in August, 1959. Its objective is to determine those factors effecting ink receptivity of printing papers during the letterpress printing of solid tones. To date, physical paper tests have been run on four papers, an electronic computer program has been written, and preliminary work toward selecting the ink for printing studies has been carried out. Total expenditures have amounted to $3200, leaving a balance of $8800 as of Jan. 1, 1960.

Converting and Consuming Division (R. C. Sturkem, General Chairman)

Plastics Committee (Wesley N. Stickel, Chairman): Grants No. 98 ($7400) in 1956, No. 120 ($2200) in 1957, and No. 149 ($2400) in 1958. Permeability of Plastic Treated Paper to Gases and Liquids. This work has been done at the State University College of Forestry at Syracuse University, under the direction of Dr. V. T. Stannett. He has stated that effective methods have been developed to measure water pickup of polyethylene and other hydrotropic films throughout the entire humidity range. The results of this method correlate closely with similar data obtained in a project by Bell Telephone Laboratories. The reports made at the 14th Annual Plastics-Paper Conference finished this project.

Dr. Stannett informed the Committee that approximately $6000 worth of equipment is available from the Permeability Project. This equipment can be used on any future project dealing with film absorption or permeability. There have been no further appropriations requested for this Project and after the final report presented at the 14th Plastics-Paper Conference this project will be completed.

It is planned to publish the results of this study in the form of a TAPPI Monograph.

Wet Strength and Interfiber Bonding Committee (K. W. Britt, Chairman): Grant No. 118 ($5250) in 1957. Study of the Fundamentals of Cure in the Development of the Wet Strength of Paper. This project, carried out at the State University College of Forestry at Syracuse University, has been completed. The TAPPI fund was exhausted sometime ago and the final stages of the work were supported by the College of Forestry. Part I of the study was published in *Tappi* 41, 465 (Sept., 1958); Part II has been submitted for publication; and Part III is in preparation.

Grant No. 161 ($10,000) in 1958. Mechanism of Retention of Wet Strength Resins. Recent work on this project has been concerned with two aspects of the adsorption of wet strength resins by cellulose fibers: (1) The role of diffusion in the adsorption process, and (2) the condition in which the resin is deposited on the fiber. Preliminary observations of stained cross sections indicate at low resin concentrations the resin is uniformly deposited on the fiber surface with little or no penetration into the fiber wall. At abnormally high concentrations, the resin seems to have penetrated the fiber wall although this may be due to illumination. The resin content of the pulp does not appear to be related to the rate of stirring. As of Dec. 1, 1959, $1930.06 of the grant had been expended. The study is being conducted at The Institute of Paper Chemistry.

Engineering Division (M. J. Osborne, General Chairman)

Chemical Engineering Committee (A. W. Plummer, Chairman): Grant No. 121 ($1400) in 1957. A Study of the Humidity Measurement in Gas Streams Containing Water-Soluble Gas at Temperatures up to 200°C. This project has been terminated. The results of the study will be presented at the 15th Engineering Division Conference in October, 1960, and will be published in *Tappi* shortly thereafter.

Fluid Mechanics Committee (C. A. Lee, Chairman): Grant No. 154 ($14,000) in 1958. Instability of Stock on the Fourdrinier Wire. This grant covers the period beginning Jan. 1, 1959, and terminating April 1, 1960. The preliminary experimental and analytical study directed at gaining an understanding of the free surface instability (spouting) of paper stock on a fourdrinier wire has been completed. Experiments have been conducted on the rebuilt test apparatus to determine the stability of a liquid film on a rotating, horizontal drum. Tests similar to those which were run earlier were repeated to obtain additional information. These will be discussed in the final project report. The unspent balance of the grant is $1719.38. The study is being carried out at the University of Michigan.

Grants No. 147 ($16,500) in 1958 and No. 172 ($17,750) in 1959. Flow Characteristics of Dilute Fiber Suspensions. Work on Grant No. 147 was begun on Nov. 1, 1958, and completed on Oct. 31, 1959, with an overexpenditure of $637.16, which will be paid out of Grant No. 172. A presentation of the results to date was given by Prof. J. W. Daily at the TAPPI Engineering Conference in Oct., 1959, Pittsburgh. Three formal reports have been issued to the committee by those conducting the study at the Massachusetts Institute of Technology. Grant No. 172 will finance the continuation of the project and it is proposed to consider the basic question of the effect of suspended solid particles on the state of turbulence of water.

Grant No. 170 ($710.71) in 1959. Friction of Stock in Fittings. The grant is being used at the University of Maine to develop the data obtained into data sheet form. This work is about two thirds completed and will not be ready until after the end of the school term this year.

Paper and Board Manufacture Division (R. C. Masterman, General Chairman)

Structural Fibrous Materials Committee (R. S. von Hazmburg, Chairman): Grant No. 108 ($1000) in 1956. Testing of Two Drainage Testers. TAPPI now has only one tester which is on test at various mills. The second tester was sold and funds derived from the sale were paid to the Association.

Grant No. 33 ($2400) in 1951. Determination of a Method of Test for the Racking Strength of Insulation Board Sheathing. To complete this project the Forest Products Laboratory has estimated that about $4500 will be required. An attempt has been made to have the expense shared with the Insulation Board Institute and this will be resolved at the 1960 meeting of the committee in February.

Grant No. 108 ($1000) in 1956. Testing of a Test Board Machine for Structural Fibrous Materials. The equipment is so large that many company laboratories are unable to use it. To rehabilitate the testing machine will require about $1000. This subject will be resolved at the February meeting of the committee.

Pulp Manufacture Division (M. B. Pineo, General Chairman)

Acid Pulping Committee (P. J. Frost, Chairman): Grant No. 66 ($5000) in 1954. Thermodynamic Properties of the Systems: Sulfur Dioxide–Water–Ammonia, Sulfur Dioxide–Water–Sodium Oxide, Sulfur Dioxide–Water–Magnesium Oxide, and Sulfur Dioxide–Water–Calcium Oxide.

Studies directed toward the experimental measurement and correlation of vapor liquid equilibria in the subject systems have continued. Mr. Ronald Fleming has finished his work for the B.S. in chemical engineering and has taken up graduate study at the University of Michigan. Mr. Herbert Gaskill is continuing his research on this topic. A new graduate student in chemical engineering at the University of Washington, Mr. William Scott—who received his Bachelor of Science degree in chemical engineering from the University of California in 1959—has taken up the problem.

Work is continuing in the generalized machine calculation system disclosed in our previous report, and the University of Washington's IBM 650 is presently being employed. Great assistance will be provided by the new IBM 704 machine which will be extensively utilized in this research when the machine becomes available, probably on April 1, 1960.

It is expected that a manuscript describing these and prior results will be submitted for publication to *Tappi* Magazine.

The funds granted by TAPPI to the University of Washington for this research are exhausted. To date, on this research topic the University has spent the funds provided by TAPPI, as well as perhaps twice this sum in addition from other sources of research funds.

Grant No. 88 ($600) in 1955. The Distribution in Molecular Weights of Lignins.

In September, 1955, a grant was made by TAPPI to the University of Washington in the amount of six thousand dollars to support research on the distribution of molecular weights of lignins. Attention was to be devoted to the study of the mechanism of delignification of wood, and especially to the delignification as brought about by sulfurous acid-bisulfite solutions under conditions which give rise to relatively high yield of wood cellulose.

Mr. Gerald Chang has now completed some 70 delignification experiments on hemlock and alder woods as well as quite a number of other experiments relating to the research activity. Delignification studies have been conducted under acidic, neutral and alkaline conditions with sodium hydroxide-sulfurous acid solutions using several temperatures and treatment times. Cellulose yields, lignin molecular weights and other characteristics have been estimated. Methoxyl evaluations have been made for many of the experiments.

It is contemplated that this work will be published in *Tappi* Magazine and the paper will also include a rather complete review of the lignin and molecular weight studies.

The funds granted to the University of Washington for this research are exhausted.

Mechanical Pulping Committee (J. K. Kirkpatrick, Chairman): Grant No. 162 ($600) in 1958. Effect of Closed White Water Systems on Groundwood Brightness by Determination of the Factors Causing Discoloration. The study has been completed and the results have been prepared for publication in *Tappi*. A total of $599.73 has been expended for the project, which was carried out at the State University College of Forestry at Syracuse University.

Pulp Purification Committee (Ferd Kraft, Chairman): Grant No. 154 ($3000) in 1958. Preparation of a Critical, Up-to-date Report Analyzing Information Available on Pulp and Paper Brightness Recession. This study is being carried out at the University of Toronto and will be completed during 1960. Up to Aug. 31, 1959, $1858.20 of the grant had been expended.

Research and Development Division (Harry F. Lewis, General Chairman)

Fundamental Research Committee (R. P. Whitney, Chairman): Grant No. 124 ($4887.82) in 1957. Behavior of Nucleophilic Reagents with Lignin and Lignin Models. This project has been completed and was under the direction of Prof. M. W. Cronyn of Reed College. Arrangements are being made for the publication of the results.

Grant No. 160 ($3443.13) in 1958. Reactions of Aqueous Chlorine with Simple Carbohydrates. This is a continued project, finished earlier by Grants No. 75 and No. 97. A paper on one of the phases of the work has been submitted to the committee and after approval will be published in *Tappi*. This type of information will provide valuable background in contributing to a better understanding of the fundamentals underlying bleaching operations. The Grant has been paid in four installments during 1959. It is expected that at least one additional paper will be submitted for publication. The work was done under the direction of Dr. Lichtin at Boston University.

Wood Chemistry Committee (J. R. Salvesen, Chairman): Grant No. 153 ($3900) in 1958. The Mechanism of Bleaching of Lignin in Aqueous Chlorine, Chlorine Dioxide and Chlorite Systems. A preliminary report and three subsequent progress reports were submitted to the committee during 1959. One half of the appropriated fund has been expended as of Jan. 14, 1960. The work is being done at the State University College of Forestry at Syracuse University.

Grant No. 165 ($4500) in 1959. Isolation of Dimers from Lignin. This project has been cancelled because of Dr. Schuerch's absence from the State University College of Forestry at Syracuse University on a Guggenheim Memorial Foundation Fellowship in London. No funds were used on this project from Grant No. 165. A balance of $185.69 left from former Grant No. 116 ($4500) was returned to TAPPI. A paper summarizing the earlier work on this project was published in *Tappi* 41, 64 (Feb., 1958). A further paper appeared in *Tappi* 42, 446 (June, 1959), and the final paper is ready for publication.

Grant No. 164 ($2885) in 1959. Preparation and properties of Polymer-homologous Oligosaccharides of the Cellulose Series. The objective of this project is to advance the study of the preparation and properties of the above compounds and by this means to interpret further the fundamental chemistry and reactivity of cellulose. The action of sodium hypochlorite on cellobiose in a solution buffered to pH 9 was studied. The acidic products obtained correspond closely to those predicable by random chain oxidation while the major products will correspond closely to the favored course of oxidation. This work is being done at the Ohio State University. Expenditures made during the period Oct. 1–Dec. 31, 1959, total $598.

Statistics Committee (M. S. Renner, Chairman): Grant No. 163 ($200) in 1958. Sampling Plans for the Acceptance or Rejection of Skid Lots of Paper. The first step in the project has been to complete a pilot run in which the sampling plan is tried out in a single mill to test the completeness and precision of the directions. Illness has delayed the work but a progress report is expected at the time of the 1960 TAPPI Annual Meeting.

Once the sampling plan directions have been "de-bugged," the remainder of the data-gathering portion of the project should be completed with a minimum of difficulty. The data it is anticipated should be gathered and analyzed in form ready for incorporation in a report by December, 1960.

To date no money has been spent on this project. There is a possibility that the recent availability of electronic computers will permit a considerable reduction in the over-all cost of the program. If experience indicates that this result can be obtained, notification will be sent to the Chairman of the Project Appropriations Committee immediately upon this fact being established.

Testing Division (C. E. Brandon, General Chairman)

Chemical Methods Committee (William K. Wilson, Chairman): Grant No. 129 ($2900) in 1957. Disperse Cellulose Viscosity. This project has been completed.

Container Testing Committee (M. J. Clark, Chairman): Grant No. 133 ($1994.50) in 1957. The Study of the Effect of Flat Crush Results of the Speed of Loading, Size of Test Specimen, Type of Loading, Shape of Test Specimen and Effect of Lateral Movement. That part of the project requiring financial assistance has been completed. The project as a whole within the committee has not been terminated. The object of the work is to develop a test method and this will require more time.

Fibrous Raw Materials Testing Committee (E. R. Schafer, Chairman): Grant No. 43 ($2500) in 1952. Species Identification of Wood and Wood Fibers. A report on "Identification of Coniferous Woods" has been prepared for publication. This will be presented at the Testing Conference in September, 1960, and will appear in *Tappi*. Development of a similar key for hardwood species is now in progress. The TAPPI grant has been entirely expended. This study has been carried out at the U. S. Forest Products Laboratory.

Grant No. 94 ($2000) in 1956. Dirt in Wood Chips. This work is being conducted by Prof. B. E. Lauer, Head of the Chemistry Department, University of Colorado. A report of the work, "The Development of Dirt Contribution Factors for Dirt in Pulpwood Chips," by Edwin Birkhimer, Trevor C. Rowland, Honorato B. Santos, and B. E. Lauer

was prepared for publication in *Tappi* after presentation at the September Testing Conference. The work involved (1) the identification and separation of dirt types; 15 basic dirt types were identified, (2) preparation of pulp from each class of dirty chips, and (3) the estimation of the dirt content of the pulps. The work on Engelmann spruce is reported on in the present report. Pulping was by the sulfite process. The project is being continued on other woods and by the alkaline and semichemical processes. The TAPPI funds allotted for this project are entirely expended.

Paper Testing Committee (L. Price, Chairman): Grants No. 143 ($2800) in 1958 and No. 171 ($2400) in 1959. Relationship and Sensitivity of Air-Leak Smoothness Testers. This project is being sponsored cooperatively with the Graphic Arts Committee at the National Bureau of Standards. The application of Mandel's "linear model" of the measuring process established the causes of some of the difficulties associated with the Sheffield and Bendtsen air-leak smoothness testers. A detailed report on this subject has been prepared for publication in *Tappi*. It has been tentatively determined that the agreement between laboratories for these air-leak smoothness methods may be appreciably improved by increasing the number of specimens tested in each laboratory and by provision and use of standard reference materials. These tentative conclusions are subject to confirmation in the general round robin now under way. Of the combined grants, $3503.82 has been expended through Nov. 28, 1959.

Precision Committee (C. A. Bicking, Chairman): Grant No. 135 ($3000) in 1957. Statistical Study of the Precision of Pulp and Paper Testing Procedures. This study has been divided into six projects and a seventh is being organized. An extensive survey has been made of the sampling and precision provisions of present test methods. Upon completion of this paper it will be presented for publication in *Tappi*. A paper on the application of precision standards has been substantially completed and will be published later. A related activity has been the analysis of data from fiber length measurement. The results will also be published. Other activities include a study of the aging of pulp, tensile test round robin, calibration of basis weight testers with metal foil, smoothness test round robin, and fluorescent brightness of paper round robin. Of the grant, $454.45 has been expended, leaving a balance of $2545.55 as of Dec. 31, 1959.

Paperboard Testing Committee (H. W. Verseput, Chairman): Grants No. 139 ($10,000) in 1957 and No. 167 ($7000) in 1959. Investigation of Smoothness and Compressibility of Paper and Paperboard as Related to Printability. In the direction of this project the following committees are cooperating: Paperboard Testing, Paper Testing, and Graphic Arts. The work under Grant No. 139 has been completed but the project is being continued with the aid of Grant No. 167. The Institute of Paper Chemistry is sharing in the expense of the work. After clearing up various mechanical problems in the nip-spreading apparatus, the primary goal was the investigation of such procedural variables as nip pressure and fluid viscosity. It was found that the surface roughness index and permeability parameter were not independent of the viscosity of the fluid used. Results indicated that the nip-spreading technique does not provide an adequate measure of printing smoothness. Publication of results will be delayed until the project is completed.

Standards Committee

All the new or revised methods approved by the Standards Committee during 1958 were published in *Tappi* by March, 1959. Eight revisions completed in 1959 presently await publication in *Tappi:* T 202 m, T 203 m, T 235 sm, T 404 m, T 421 m, T 492 sm, T 639 m, and T 685 sm.

A series of unusual happenings has delayed the 1959 issue of the methods completed during 1958. However it is expected that the methods will have been mailed to the membership by the time this report is received. One of the principal delays was caused by a belated decision to send the copy for the corrected methods to the chairmen of the interested committees for their approval and suggestions. This was worthwhile, and it is planned to schedule this procedure earlier in 1960 to avoid another undue delay.

The 1959 loose-leaf issue will include, besides the new Alphabetical and Numerical Index, two new methods: T 21 sm and T 490 sm; 10 revised methods: T 7 m, T 15 m, T 20 m, T 211 m, T 227 m, T 413 m, T 452 m, T 608 m, T 609 m and T 630 m; and 11 corrected methods: T 1 m, T 4 m, T 5 m, T 6 m, T 11 m, T 12 m, T 218 m, T 427 m, T 441 m, T 458 m, and T 616 m.

These two new, 10 revised, and 11 corrected methods in the 1959 issue compare with a past annual average performance of 5.8, 4.6, and 11.5, respectively. In addition Official Standard T 447 m, Moisture Expansivity of Paper, was withdrawn pending its revision. Although the revision of Official Standard T 602 m, Analysis of Sulfuric Acid, was approved by the requisite majority of the membership when balloted, the adverse criticism expressed by those opposed, made it desirable to resubmit the method to the originating committee for further study.

A ballot form to be included in the 1959 loose-leaf issue requests votes for the following eight Revisions of Official Standards which were completed in 1959: T 2 m, T 3 m, T 208 m, T 220 m, T 425 m, T 439 m, T 600 m, and T 612 m. These make a total of 21 new or revised methods completed during 1958 and subsequently published in *Tappi*.

In contrast, only 10 new or revised methods were completed during 1959. They are as follows:

New Tentative Standard

T 236 m, Kappa Number of Pulp, Chemical Methods Committee. (Approved by Standards Committee, October, 1959; Published in *Tappi*, November, 1959.)

New Suggested Methods

T 492 sm, Water-Drop Absorbency Test for Paperboard, Paperboard Testing Committee. (Approved by Standards Committee, August, 1959; to be published in *Tappi*.)

T 695 sm, Modulus of Rupture of Paraffin Wax, Joint TAPPI-ASTM Wax Testing Committee. (Approved by Standards Committee, December, 1959; to be published in *Tappi*.)

Revised Official Standards

(These will be published in the 1961 loose-leaf issue if approved by membership ballot in 1960.)

T 202 m, Chlorine Consumption of Pulp, Chemical Methods Committee. (Approved by Standards Committee, July, 1959; to be published in *Tappi*.)

T 404 m, Tensile Strength of Paper, Paper Testing Committee. (Approved by Standards Committee, October, 1959; to be published in *Tappi*.)

T 421 m, Qualitative Analysis of Mineral Filler and Mineral Coating of Paper. Chemical Methods Committee. (Approved by Standards Committee, November, 1959; published in *Tappi*, January, 1960.)

Revised Tentative Standards

T 203 m, Alpha-Beta- and Gamma-Cellulose in Pulp, Chemical Methods Committee. (Approved by Standards Committee, December, 1959; *Tappi*, February, 1960.)

T 235 m, Solubility of Pulp in Cold Sodium Hydroxide, Chemical Methods Committee. (Approved by Standards Committee, December, 1959; *Tappi*, February, 1960.)

T 639 m, Needle Penetration of Paraffin Wax. Joint ASTM-TAPPI Wax Testing Committee. (Approved by Standards Committee, December, 1959; February, 1960.)

Revised Suggested Method

T 481 sm, Fiber Orientation of Paper (Zero-Span Tensile) Paper Testing Committee. (Approved by Standards Committee, August, 1959; published in *Tappi*, November, 1959.)

In addition to the above the following methods were also considered by the Standards Committee during 1961.

T 489 m, Stiffness of Paperboard. Paperboard Testing Committee. Received April, 1959, returned to originating committee with suggested modifications June, 1959.

T 406 m, Reducible Sulfur in Paper. Chemical Methods Committee. Received April, 1959. Sent out for Standards Committee vote May, 1959. Modifications are presently being considered by originating committee.

T 419 m, Starch in Paper. Chemical Methods Committee. Received September, 1959. Sent for Standards Committee vote October, 1959. Some modifications appear desirable and are presently being considered by originating committee.

The Alkaline Pulping Committee sent a method for the analysis of black liquor. This was referred to the Routine Control Methods Committee. The Water Committee recently sent a method for measuring the turbidity of water. This was returned with the suggestion that they request the National Bureau of Standards to supply a certified clay material with which to prepare reference standards and thereby greatly simplify the test.

The Chemical Methods Committee under the chairmanship of Earl S. McColley turned in a very good performance this year as it did last year. His recent resignation as chairman of that committee is regretted.

Again the Standards Committee wishes to thank the Australian, British, Canadian, and German technical associations for their helpful criticisms of the draft of TAPPI methods which are sent to them at the same time as to members of the Standards Committee. As these correspondents will see in the texts of the methods as published in *Tappi* or in loose-leaf form, many of their suggestions have been accepted.

Because of a number of added duties, J. L. McCarthy felt it necessary to resign from the Standards Committee in June, 1959. The Committee was fortunate in persuading A. H. Nadelman to take his place.

The Committee welcomes as a new member, Earl S. McColley, who has just recently resigned the chairmanship of the Chemical Methods Committee after several years of very effective work.

Respectfully submitted,

B. L. Browning, The Institute of Paper Chemistry
W. Boyd Campbell, Montreal, P. Q.
G. H. Chidester, U. S. Forest Products Laboratory
W. F. Holzer, Crown Zellerbach Corp.
E. C. Jahn, New York State College
F. D. Long, Container Corp. of America
A. H. Nadelman, Western Michigan University
W. R. Willets, Titanium Pigment Corp.
James d'A. Clark, Oregon State College, *Chairman*

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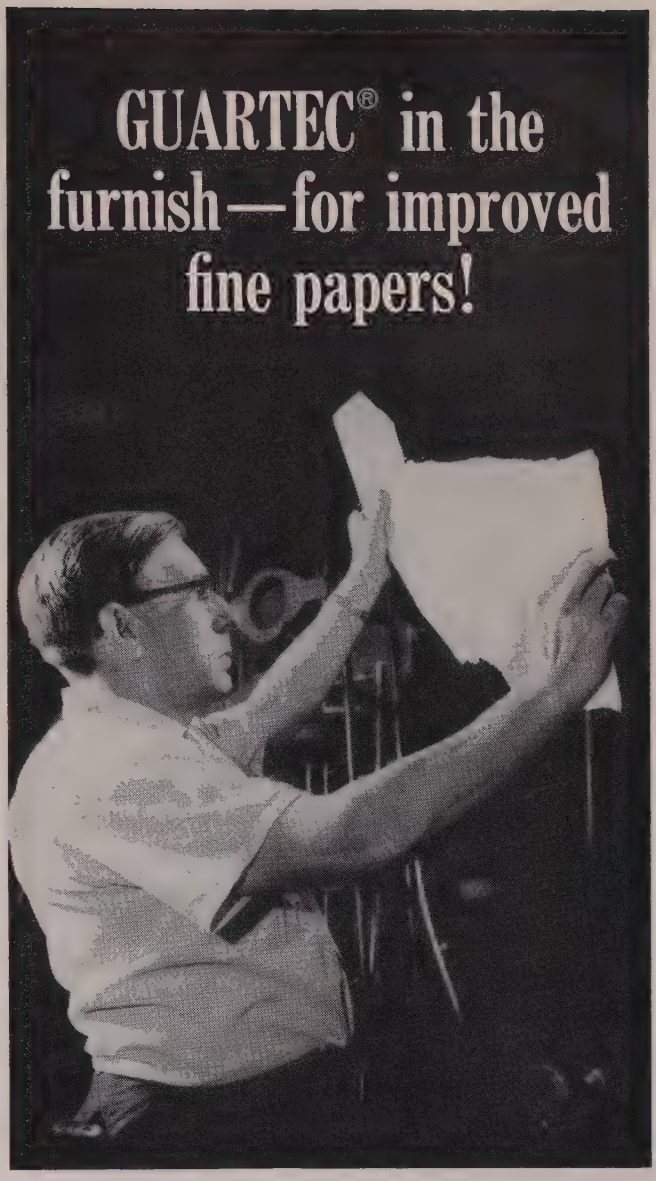

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TAPPI PROFILES

Harold M. Annis

Harold M. Annis, vice-president of TAPPI, is also vice-president directing research and development of the Oxford Paper Co., a leading manufacturer of printing papers.

His association with the paper industry began early in life. Born in 1905 in Chillicothe, Ohio, hometown of the Mead Corp., Mr. Annis went to work for this paper company at the age of 18, one year before he entered Miami University in Oxford, Ohio. He did not complete his course in 4 consecutive years but preferred to gain practical experience working for Mead in alternate years. Graduating in 1929, Mr. Annis joined the technical service department of the Mead Corp., where he was largely concerned with the manufacture of coated paper. In 1932 he became technical director of Allied Paper Mills in Kalamazoo, Mich.

For the last 23 years he has been with the Oxford Paper Co., which he joined in New York City in 1937 as assistant to the vice-president in charge of manufacturing. With the introduction of machine coated papers at Oxford, Mr. Annis organized and trained a sales service department and became manager of sales service in 1947. He was made manager of product development in 1948, technical director of research and development in 1950, and in 1958 was elected vice-president in charge of research and development.

He became a member of TAPPI in 1932 and is past chairman of the Kalamazoo Local Section, which has close relations with the superintendent's association PIMA. Pursuing his strong interests in the coating field, and particularly in the manufacture of coated printing papers and their relationship to the graphic arts, Mr. Annis was active on the TAPPI Coating Committee, and was division chairman of the Coating and Graphic Arts Division. He became a member of the Executive Committee in 1956. In 1958 he was chairman of the Medal Awards Committee and is at present chairman of the Publications Management Committee and of the Membership Relations Committee.

He was elected vice-president of the Association at the 1959 Annual TAPPI Meeting.

In addition to his work in TAPPI, Mr. Annis faces a full schedule of committee activities in the pulp and paper industry and in the graphic arts. He is a member of the Operating Committee of the National Council of Stream Improvement, and the Research Committee of the Lithographic Technical Foundation. Independently of his associations in TAPPI, he is a member of both the Technical and the Classifications and Definitions Committee of the APPA. On the latter committee, he is responsible for reviewing the definitions of the coating and graphic arts terminology for the 3rd edition of the *Dictionary of Paper*.

With more than 30 years in the paper industry to his credit, Harold Annis is well aware of its needs and the necessity to arouse further interest in it, especially among students. In 1947, at the request of university officials, he organized a course of lectures on pulp and paper for the New York University School of Adult Education. These lectures were given by people prominent in their field and were held in the Concert Hall of the Barbizon Plaza. Where about 75 people only were expected to register, the number of registrants reached 549. At present Mr. Annis combines business trips with stopovers at colleges where he keeps students informed of the increasing opportunities the paper industry has to offer.

Harold Annis is a member of the Chemists Club and the Camp Fire Club of America. Both he and his son Stephen, 22, are avid sports car racing enthusiasts.

Married to the former Florence Roth, he and his family live in Chappaqua, N. Y.

TAPPI NOTES

Over Ten Thousand Members!

"DECEMBER 31, 1959. TAPPI Membership Surpasses 10,000 Mark! Association Closes 1959 with 9624 Individual and 530 Company Members—10,154 Members in 43 States and 55 Countries."

Forty-five years ago when the Association was founded, a forecast of such membership by 1960 would probably have been ridiculed. TAPPI then had 201 individual members. From this modest beginning the early growth was gratifyingly steady if not spectacular. During the depression years of 1920–21 and 1932–34 there were brief dips in the membership figures, but by 1940 TAPPI'S total membership had climbed to over 1900. At the start of what historians are already calling the "Fabulous Fifties" this figure had jumped to 4400. Late last year, only one decade later, it was clearly over 10,000.

This 130% surge in membership over the past ten years can be attributed to several factors. For one, the United States pulp and paper industry has grown remarkably both in size and in the complexity of its technology during this period. These changes have drawn increasing numbers of technically trained men into the industry and into Association membership. The expansion of TAPPI committee and local section activities into converting, printing, and container operations has attracted many new members from these related technologies. And finally, a growing appreciation overseas of TAPPI publications and of the benefits of technical cooperation on an international level has pushed overseas memberships from 455 in 1950 to 1800 today.

It is heartening to note that the record membership was attained in spite of the higher level of TAPPI dues established last year. During 1957 and 1958 Association operating expenses ran considerably ahead of operating income. Faced with the prospect that these expenses would continue to exceed current income, the Executive Committee last year authorized the first increase in Association dues in over 30 years. It was expected that the higher dues might not only deter prospective members but even force some present members to resign. Consequently the surge in membership over the 10,000 mark last year was particularly gratifying.

Some TAPPI members do resign every year, of course, but their numbers have been more than offset by new members joining the Association. During the last 10 years, for example, an average of 4.5% of our individual TAPPI members have resigned each year, but they have been replaced by new members each year averaging 12.7% of the total. Changes in corporate and sustaining memberships have shown less variation, averaging an annual gain of 7.0% in new members and an annual loss of 3.5% through resignations.

Unless there is an unexpected change in this pattern, roughly 400 TAPPI members will resign or have their names dropped from the membership roster during 1960. Of those who will give reasons for this action, the greatest number will probably resign because their work is no longer related to the technical operations of our industry. Some will be retiring from active work, some will have moved into other industries, and others remaining in the paper industry will have transferred into assignments of a less technical nature. Other reasons given for resignation in past years include inability to attend TAPPI meetings, lack of time for reading TAPPI publications, insufficient benefits received for the dues paid, personal reasons, availability of TAPPI publications through other TAPPI members in the same company, and changes in company managements and policy.

With the increasingly important role of science and technology in our industry and in our country, we believe that TAPPI's programs and services have never been more worthy of support than they are today. *If, however, for reasons beyond an individual's control, resignation in 1960 is necessary, the headquarters office should be notified promptly. It is not adequate simply to ignore the 1960 dues bill and the reminders which will follow it, while continuing to receive TAPPI publications.* As a courtesy to those members who may be delayed in paying their 1960 dues, all 1959 members are carried on the Association's mailing lists through the first 3 months of the new year, unless they give formal notice of their desire to resign.

In applying for membership each TAPPI member agrees to abide by the Association Constitution and Bylaws. To resign in good standing the TAPPI Bylaws require that a member notify the secretary and pay dues for the half year in which the resignation becomes effective. It is easy, of course, for members to forget what was signed years ago. That is why we are reminding you now. We hope no one will resign, but if it is necessary, please notify us promptly.

Philip E. Nethercut

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Thomas R. Alexander, Research and Development Chemist, British Sisalkraft Ltd., Kent, England, a 1951 graduate of University of London.

William H. Algar, Research Laboratory Superintendent, Australian Paper Manufacturers Ltd., Melbourne, Australia, a 1945 graduate of Royal Melbourne Technical College.

Justino, Aray, Paper and Board Tester, Papelera Industrial, S.A., Caracas, Venezuela.

Raymond B. Aufmuth, Chief Engineer, H. K. Ferguson Co., Cleveland, Ohio, a 1939 graduate of Fenn College.

Paolini Augusto, Superintendent, Coating Dept., Ambrogio Binda, Milano, Italy, a 1935 graduate of Industrial Technical Institute, Como.

James Bain, Technical Specialist, Union Carbide Plastics Co., Bound Brook, N. J.

Eugene G. Barradas, Quality Control Supervisor, Fibreboard Paper Products Corp., Antioch, Calif., a 1947 graduate of the University of Minnesota.

S. B. Batra, Manager, Tissue Mill, The Bharat Carbon & Ribbon Mfg. Co. Ltd., New Delhi, India, a 1929 graduate of Thomason Engineering College.

James L. Belden, Assistant Manager, New Product Development, Paramonga Paper and Board Div., Grace y Cia, Lima, Peru, a 1936 graduate of Bowdoin College.

Jean P. A. Bellet, Chief Engineer, Societe Fives Penhoet, Paris, France, a 1942 graduate of Central School of Arts and Manufacturing.

Dale E. Benjamin, Research Chemist, Potlatch Forests, Inc., Lewiston, Idaho, a 1949 graduate of University of Idaho.

Giuseppe Bianchi, Director, Cartificio Ermolli Di Moggio Udinese S.p.A , Milano, Italy, a 1928 graduate of Milano Polytechnic Institute.

Martin S. Bolduc, General Superintendent, Hennepin Paper Co., Little Falls, Minn.

Geza B. Boray, Mill Chemist, Quality Control, Hinde and Dauch Paper Co. of Canada, Ltd., Trenton, Ont., Canada, a 1954 graduate of Graz Technical University, Austria.

John J. Burke, Jr., Salesman, Draper Bros., Canton, Mass., attended Columbia College.

George T. Butts, Supervisor, Adhesive Technical Service, Colton Chemical Div., Air Reduction Inc., Cleveland, Ohio, a 1953 graduate of University of Oklahoma.

Stig Carlson, Engineer, Joh. Sjo, A/B, Norrkoping, Sweden, a 1948 graduate of N.K.I. College, Stockholm.

Ian E. J. Cathels, Mill Manager, Australian Paper Manufacturers Ltd., Victoria, Australia, a 1948 graduate of the University of Sydney.

Raymond P. Citko, Technical Salesman, Corn Products Sales Co., Chicago, Ill., a 1952 graduate of Loyola University.

Richard E. Coleman, Salesman, H. B. Fuller Co., Cincinnati, Ohio.

Joseph S. Cooper, Product Research Analyst, Lodding Engineering Corp., Auburn, Mass. Attended Clark University.

Charles D. Cutts, Manager, Export Div., Canadian Ingersoll Rand Co. Ltd., Montreal, Que., Canada. Attended Felsted College.

Lionel T. Donaldson, Research Chemist, Metal Box Co. of South Africa Ltd., Cape Town, South Africa, a 1955 graduate of the University of Cape Town.

Robert L. Doyle, Supervisor, Abrasive Laboratory, Minnesota Mining and Mfg. Co., St. Paul, Minn., a 1950 graduate of Kansas State College.

Nathan C. Eastman, Chemist, Union Carbide Chemicals Co., So. Charleston, W. Va., a 1939 graduate of University of New Hampshire.

Nils Ekstrom, Director, Holmens Bruks och Fabrika A/B, Hallstavik, Sweden. Attended Technical University, Darmstadt.

Masao Ezaki, Chief, Productive Planning Div., Kanzaki Paper Mfg. Co., Ltd., Tokushimaken, Japan, a 1949 graduate of Osaka University.

William P. Fairchild, Research Chemist, The Kelco Co., San Diego, Calif., a 1951 graduate of Kansas State University.

Jandyr G. J. Falzoni, President, Estabelecimento Nacional Industrial De Anilinas S/A "ENIA," Sao Paulo, Brazil. Attended Sao Paulo Chemical University.

Edel Farres, General Manager, Cuban Technical Research Institute, Havana, Cuba.

Charles D. Fawkes, Technical Sales Representative, Pyroxylin Products, Inc., Chicago, Ill. Attended Illinois Institute of Technology.

Edgar H. Foster, Mill Manager, Cellulose Australia Ltd., Adelaide, South Australia.

William A. Foster, Student, The Institute of Paper Chemistry, Appleton, Wis.

Norman G. Gaylord, Vice-President, Polymer Div., The Western Petrochemical Corp., Newark, N. J., a 1950 graduate from Polytechnic Institute of Brooklyn with a Ph.D. degree.

F. Claus Globig, Project Engineer, The Champion Paper and Fibre Co., Hamilton, Ohio, a 1958 graduate of Technical University of Darmstadt with a D.Eng. degree.

Lynn P. Gordon, Technical Assistant to Superintendent, Mosinee Paper Mills, Mosinee, Wis., a 1956 graduate of University of Wisconsin.

Mary T. Gormley, Librarian, Technical Service Div., American Can Co., Maywood, Ill., a 1949 graduate of Mundelein College.

John L. Grettum, Chemist, The Mead Corp., Escanaba, Mich., a 1958 graduate of Western Michigan University.

Thomas B. Hiare, Manufacturing Engineer, Continental Can Co., New York, N. Y., a 1944 graduate of Lafayette College.

Warren M. Hammel, Associate Research Chemist, Champion Paper and Fibre Co., Hamilton, Ohio, a 1932 graduate of Washington University.

Thomas J. Henry, Sales Engineer, John W. Bolton and Sons, Inc., Lawrence, Mass. Attended Tri-State Engineering College.

Massanobu Hirata, Chief Chemist, Zen-Ko-Ren, Kanagawaken, Japan, a 1938 graduate of Tokyo University.

William B. Hogg, Vice-President, Hayden Wire Works, Inc., West Springfield, Mass.

Philip C. Holladay, Jr., Chemist, Shell Chemical Div., Shell Oil Co., Union, N. J., a 1956 graduate of Virginia Polytechnic Institute.

Satoru Iwanaga, Chief of Planning Section, Yuko Seitai K.K., Osaka, Japan.

Paul A. Johnson, Graduate Student, The Institute of Paper Chemistry, Appleton, Wis., a 1956 graduate of University of Washington.

Richard M. Johnson, Assistant Superintendent, Waldorf Paper Products, St. Paul, Minn., a 1952 graduate of St. Cloud College.

Ermo Kaila, Research Director, AB J. W. Enqvist Oy Pulp Mills, Lielahti, Tampere, Finland, a 1951 graduate of University of Helsinki.

Lauri Kerkola, Technical Manager, Tervakoski Osakeyhtio, Tervakoski, Finland, a 1949 graduate of Technical University of Helsinki.

Bernard L. Kline, Manager, Chemical Laboratories, Western Union Telegraph Co., New York, N. Y., a 1925 graduate of Brooklyn Polytechnic Institute.

Ronald C. Klye, Technical Superintendent, Australian Paper Manufacturers Ltd., Sydney, Australia, a 1942 graduate of Melbourne Institute of Technology.

Keiji Kojima, Researcher, Sumitomo Electric Industries, Ltd., Osaka, Japan, a 1956 graduate of Tokyo University.

Magohachi Koshio, President, Abekawa Kogyo Co., Ltd., Shizuoka-Pref., Japan, a 1902 graduate of Tokyo Agricultural College.

Daniel J. Kuebel, Research Project Engineer, Champion Paper and Fibre Co., Hamilton, Ohio, a 1932 graduate of University of Dayton.

Austin Le Strange, Representative, Southern Pulp and Paper Manufacturer Magazine, Atlanta, Ga.

Fritz A. Maier, Technical Service Representative, St. Regis Paper Co., New York, N. Y., a 1954 graduate of New York State College of Forestry.

Gerard J. Mangin, Research Engineer, Cartonnerie De La Rochette, Aisne, France, a 1954 graduate of the French School of Paper.

Claude Marro, Technical Director, W. R. Grace & Cia, Lima, Peru, a 1945 graduate of Technical University, Zurich.

Robert J. Martini, Vice-President and General Manager, Huyck Equipment Div., Huyck Corp., New York, N. Y., a 1941 graduate of Massachusetts Institute of Technology.

Joseph R. Massa, Assistant Chemist, Scott Paper Co., Chester, Pa. Attended Drexel Technical Institute.

William D. May, Research Physicist, Pulp and Paper Research Institute of Canada, Montreal, Que., Canada.

Robert N. Maynard, Research Chemist, J. M. Huber Corp., Huber, Ga., a 1950 graduate of Mercer University.

Frank J. McGovern, Western Manager, The Lummus Co., New York, N. Y. Attended University of Michigan.

Lewis T. Milliken, Chemist, National Bureau of Standards, Washington, D. C., a 1944 graduate of Bowdoin College.

Robert L. Mitchell, Jr., Secretary, The Chlorine Institute, Inc., New York, N. Y., a 1943 graduate of Massachusetts Institute of Technology.

Dennis E. Mooney, Assistant Sales Manager, Elliott Brothers (London) Ltd., Lewisham, London, England.

Tsunechika Morizane, President, Morizane Iron Works Mfg. Co. Ltd., Ehime-Pref., Japan.

Morris Mulman, Application Engineer, Mixing Equipment Co., Rochester, N. Y., a 1951 graduate of University of New Hampshire.

Uemoto Nagatoshi, President and Chief Engineer, K. K. Futaba Seisaku-sho, Hyogo-Pref., Japan

Yuzo Nakajima, Mill Manager, Takasaki Seishi Co., Tochigi-Pref., Japan, a 1933 graduate of Sendai Technical College.

James M. Naughton, District Sales Representative, Olin Mathieson Chemical Corp., a 1947 graduate of Canisius College.

George S. Petty, Sales Representative, Riordon Sales Corp. Ltd., Montreal, Que., Canada, a 1954 graduate of McGill University.

Richard W. Phelps, General Manager, Dilt Div., Black-Clawson Co., Fulton, N. Y.

H. G. Psyras, Technical Director, Union Paste Co., Hyde Park, Mass., a 1952 graduate of Northwestern University.

Viora Riccardo, Research Laboratory, Italia Olandese Enda S.p.A., Palestro (Pavia), Italy.

Herbert E. Riedel, Assistant Technical Superintendent, International Paper Co., No. Tonawanda, N. Y., a 1949 graduate of Rensselaer Polytechnic Institute.

Ferretti Rinaldo, Manager of Manufacturing, Cartiere Paolo Pigna S.p.A., Alzano Lombardo (Bergamo), Italy, a 1952 graduate of University of Milano, with a D.Chem.Ind. degree.

Harvey H. Robbins, Executive Secretary, Paraffined Carton Research Council, Chicago, Ill., a 1931 graduate of University of California.

Dennis M. Ross, Analytical Chemist, Cascade Kraft Corp., Wallula, Wash., a 1959 graduate of University of Idaho.

Glenn H. Roundy, Consultant, Thompson, Ramo, Wooldridge, Cleveland, Ohio. Attended University of Massachusetts.

William J. Ryan, Librarian, Columbia-Southern Chemical Corp., Barberton, Ohio, a 1955 graduate of Mt. Union College.

Jerome F. Saeman, Chief, Div. of Wood Chemistry, U. S. Forest Products Laboratory, Madison, Wis., a 1942 graduate of University of Wisconsin, with a Ph.D. degree.

Toshio Sagara, Chief, Industrial Machine Engineering Dept., Shibaura Machine Works, Ltd., Shizuoka-Pref., Japan, a 1940 graduate of Shizuoka Engineering College.

Necmi Sanyer, Supervisory Chemist, U. S. Forest Products Laboratory. Madison, Wis., a 1953 graduate of New York State College of Forestry.

William T. Sargent, Physicist, Continental Can Co., Inc., Uncasville, Conn., a 1959 graduate of University of Connecticut.

Motoo Saruhashi, President, Saruhashi Paper Manufacturing Institute, Inc., Tokyo, Japan, a 1940 graduate of Kogakuin College.

Maxwell M. Schirtzinger, Sanitary Engineer, The Mead Corp., Chillicothe, Ohio, a 1954 graduate of Ohio State University.

Delbert B. Schuster, Chemist, Caradco Inc., Dubuque, Iowa, a 1952 graduate of Platteville State College.

W. Schmidt, Research Engineer, Hermann Research Laboratories, Berlin, Germany, a 1935 graduate of Humbolt University.

Richard R. Senz, Staff Metallurgist, Aluminum Co. of America, Pittsburgh, Pa., a 1936 graduate of Case Institute of Technology.

Curtis M. Shanahan, Technical Superintendent, Container Corp. of America, Los Angeles, a 1936 graduate of Northwestern University.

Harry W. Sherman, Tour Foreman, Sulfate Dept., Bowaters Southern Paper Corp., Calhoun, Tenn., a 1959 graduate of Tennessee Wesleyan College.

Manjiro Shrai, Research Engineer, Mitsubishi Denki K.K., Hyogo-ken, Japan. Attended Tokyo University.

John C. Spicer, Chemical Engineer, Union Carbide Chemicals Co., So. Charleston, W. Va., a 1945 graduate of Rensselaer Polytechnic Institute.

Donald D. Stevenson, Chief Forester, Buckeye Cellulose Corp., Foley, Fla., a 1935 graduate of Yale University.

E. Gerald Strass, Plant Chemist, Coates Board and Carton Co., Stroudsburg, Pa., a 1952 graduate of De Paul University.

Richard C. Sturm, Technical Serviceman, Diamond Alkali Co., Painesville, Ohio, a 1950 graduate of Hiram College.

J. Merlin Taddy, Plant Engineer, Marathon Div., American Can Co., Ashland, Wis., a 1942 graduate of Marquette University.

David B. Tenney, Treasurer-Salesman, Pratt Paper Co., Boston, Mass., a 1940 graduate of University of Virginia.

Raymond L. Thornton, Microbiologist, Buckman Laboratories, Inc., Memphis, Tenn., a 1952 graduate of University of California.

Henry M. Tobey, Manager, Technical Service and Development, Chapman Chemical Co., Memphis, Tenn.

Kido Toichi, President, Suita Paper Manufacturing Co., Ltd., Osaka Pref., Japan, a 1935 graduate of Tokyo Imperial University.

John M. Vaughan, Student, The Institute of Paper Chemistry, Appleton, Wis., a 1955 graduate of Tulane University.

Frederick Von Voightlander, Professional Engineer, Cummins & Barnard, Inc., Ann Arbor, Mich., a 1927 graduate of University of Michigan.

Reginald L. Wakeman, Director of Technical Research, Packaging Corp. of America, Grand Rapids, Mich., a 1926 graduate of Massachusetts Institute of Technology with a Ph.D. degree in 1930.

Robert A. Wamsley, Research Chemist, Research Div., The Crossett Co., Crossett, Ark., a 1951 graduate of Central Missouri State College.

Marshall L. Weingardner, Assistant General Manager, Empire Corrugated Container Corp., Jamaica, N. Y., a 1951 graduate of University of Michigan.

John J. Weitz, Technical Sales Representative, Rohm & Haas, Philadelphia, Pa., a 1952 graduate of College of Puget Sound.

Moira T. Welch, Technical Librarian, Chemical and Plastics Div., Food Machine & Chemical Corp., Baltimore, Md.

Robert Welsh, Jr., Sales Representative, Sandoz, Inc., New York, N. Y., a 1948 graduate of Cornell University.

Pauli O. Wendelin, Research Chemist, West Virginia Pulp and Paper Co., Covington, Va., a 1952 graduate of University of Helsinki.

Henri F. Wesenhagen, General Manager, N. V. Hollandsche Kunstzijde Industrie, Breda, Holland, a 1942 graduate of Technical University, Delft.

Maurice B. Wilver, Student, International Paper Co., Mobile, Ala. Attended North Carolina State College.

John D. Winkelman, Project Chemist, Cascade Kraft Corp., Wallula, Wash., a 1957 graduate of University of Oregon.

Carlton T. Wise, Head, Chemical & Sanitary Dept., J. E. Sirrine Co., Greenville, S. C., a 1929 graduate of Clemson College.

W. Jack Young, Salesman, Chas. Pfizer & Co., Inc., Clifton, N. J., a 1956 graduate of Oregon State College.

Willard O. Youngs, City Librarian, Seattle Public Library, Seattle, Wash., a 1932 graduate of University of California.

Donald M. Zoller, Research Project Engineer, Champion Paper & Fibre Co., Hamilton, Ohio, a 1941 graduate of Cincinnati.

Appointments

Corliss W. Abbott, formerly of Sherwin-Williams Co., is now in the Technical Sales Department of Southern Clays, Inc., Kalamazoo, Mich.

William H. Aiken, formerly of Diamond-Gardner Corp., is now Vice-President in charge of research and development of Personal Products Corp., Milltown, N. J.

John W. Albrecht, Technical Service Representative of Hercules Powder Co., has been transferred from Kalamazoo, Mich., to Wilmington, Del.

William V. Arvold, Jr. is now Vice-President in Charge of Manufacture for the Wausau Paper Mills, Brokaw, Wis.

Clifton P. Boutelle, formerly of Diamond-Gardner Co., is now Technical Superintendent of Coating for the Weyerhaeuser Timber Co., Longview, Wash.

Jack N. Brown is now Manager of the Pulp and Paper Department of the Swenson Evaporator Co., Harvey, Ill.

Robert F. Caswell of St. Regis Paper Co. has been transferred from Deferiet, N. Y., to Sartell, Minn., as Technical Superintendent.

George A. Clink is now Assistant Vice-President of the Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.

Robert R. Crowe, formerly of the U. S. Navy, is now a Manufacturing Apprentice for the International Paper Co., Palmer, N. Y.

William G. Dedert is now Manager of Research and Development for the Swenson Evaporator Co., Harvey, Ill.

Louis A. DelaGrange, formerly of West Virginia Pulp and Paper Co., is now Director of Maintenance and Power for the Hamilton Paper Co., Miquon, Pa.

Robert R. Digby, formerly of Eichleay Corp., is now Executive Vice-President of Roy C. Clark, Inc., East Chicago, Ind.

Douglas Duncan, formerly of Mississquoi Corp., is now technical Assistant to the Vice-President in charge of mill operations of the Krueger Organization, Ltd., Montreal, P. Q., Canada.

Thomas R. Elmblad of the Swenson Evaporator Co. has been transferred from Pittsburgh, Pa., to Cleveland, Ohio, as Manager.

Newell W. Emery, Jr., formerly of Scott Paper Co., is now Technical Director of Ames Harris Neville Co., Berkeley, Calif.

John A. Fachet is now Vice-President in Charge of Manufacture for Thwing-Albert Instrument Co., Philadelphia, Pa.

Homero L. Galindo is now Pulp Mill Superintendent of Celulosa de Chihuahua, Chihuahua, Mexico.

Rex W. Gingrich, formerly of the Whiting Corp. (Canada) Ltd., is now the Canadian Sales Representative of the Buflovac Equipment Division, Blaw-Knox Co., Buffalo, N. Y.

Robert F. Ginn, formerly Student at The Institute of Paper Chemistry, is now a Development Engineer for the National Vulcanized Fibre Co., Yorklyn, Del.

Frank H. Glass is now Production Manager of the Corrugated Division of Green Bay Box Co., Green Bay, Wis.

Ralph E. Green is now Vice-President for Technical Sales and Quality Control of Thwing-Albert Instrument Co., Philadelphia, Pa.

Bruce D. Hartel, formerly of Shartle Bros. Machine Division, is now Sales Engineer for E. D. Jones Corp., Los Altos, Calif.

Blanton W. Haskell of Rayonier, Inc., has been transferred from Fernandina Beach, Fla., to Jesup, Ga., as Resident Manager.

Leonard G. Hill, formerly with Columbia Southern Chemical Corp., is now Production Development Assistant for the Hammermill Paper Co., Erie, Pa.

W. O. Hisey, formerly of Boise Cascade Corp., is now with Lyddon & Co., London W. 1, England.

Roy W. Hodgkinson, formerly of Reed Corrugated Cases, Ltd., is now Head of the Technical Services Section of the Packaging Division of Albert E. Reed & Co., Ltd., New Hythe, Kent, England.

Charles W. Hoffman, Midwest Sales Manager of Riegel Paper Corp., has moved his office from Edinburg, Ind., to Indianapolis, Ind.

Karl Holt, formerly of Scott Paper Co., is now Process Control Engineer for the Westminster Paper Co., New Westminster, B. C., Canada.

Norman G. Holz is now Plant Engineer of Bowaters Southern Paper Co., Calhoun, Tenn.

William Holtzman, formerly of Hudson Pulp & Paper Corp., is now a Group Leader for Paper Research and Development for the Glidden Co., Baltimore, Md.

Donald A. Hughes of R. T. Vanderbilt Co. has been transferred from Kalamazoo, Mich., to New York, N. Y., as a Development Engineer.

Fred D. Iannazzi, formerly of Spaulding Fibre Co., is now a Chemical Engineer with Arthur D. Little, Inc., Cambridge, Mass.

Alfred C. Junge is now Vice-President in Charge of Sales for Clinton Corn Processing Co., Clinton, Iowa.

Stuart E. Kay is now Vice-President and Director of Research for the International Paper Co., New York, N. Y.

Theodore J. Kayhart, formerly of the Riegel Paper Corp., is now Manager of Engineering of the King Monarch and Bryant Divisions of Allied Paper Corp., Kalamazoo, Mich.

Gregory Klebanoff, Jr., formerly of Bulkley, Dunton Processes Co., is now Assistant Sales Manager of the Waste Treatment Department of Pfaudler Permutit, Inc., New York, N. Y.

Frank A. Knight is now Division Manager of Eastern Fine Paper & Pulp Division of Standard Packaging Corp., Bangor, Me.

Ralph J. Knoll is now Production Manager of Scott Paper Co., Chester, Pa.

Chester L. Knowles, formerly of Knowles Associates, is now an Engineer for H. K. Ferguson Co., New York, N. Y.

Jean M. Lambert, formerly of Dominion Containers Ltd., is now Sales Manager for Champlain Paper Box Ltd., Quebec, P. Q., Canada.

John Lewis, formerly of the Lowell Technological Institute, is now with the Pulp and Paper Research Institute, Lawrence, Mass.

Joseph T. Loomer is now Manager of Bleached Board Technical Development, Gair Products Group, Continental Can Co., New York, N. Y.

Richard C. MacDonald is now Control Superintendent for Bowaters Southern Paper Corp., Calhoun, Tenn.

Hans Maier, formerly of the St. Lawrence Corp., is now Design Engineer for the Continental Paper Division, Canadian International Paper Co., Pointe aux Trerubles, P. Q., Canada.

Robert E. Marks of the Sharples Co. has been transferred from Philadelphia, Pa., to Atlanta, Ga., as District Manager.

Spiro A. Mavros of Owens-Illinois Glass Co. has been transferred from Toledo, Ohio, to Chicago, Ill., as Quality Control Director.

Richard J. Murtaugh, formerly of St. Regis Paper Co., is now Works Chemist for Congoleum-Nairn, Inc., Cedarhurst, Md.

Harley E. Nelson, formerly of Allied Paper Corp., is now Production Manager of Kimberly-Clark Corp., Neenah, Wis.

George B. Nicholson, Jr., formerly of Federal Paperboard Co., Inc., is now Manager of Manufacture for the Downingtown Paper Co., Downingtown, Pa.

Edward H. Nunn, formerly of St. Francisville Paper Co., is now Assistant to the General Manager of Crown Zellerbach Corp., Camas, Wash.

August G. Oberland, formerly of Elgin Corrugated Box Co., is now a Sales Representative for S & S Corrugated Paper Machine Co., Chicago, Ill.

Martin J. O'Leary is now a Project Research Leader at the National Bureau of Standards, Washington, D. C. Mr. O'Leary recently observed the 50th anniversary of his association with the paper industry, 20 years with American Writing Paper Co. and other manufacturers, and 30 years with the National Bureau of Standards where he was, until recently, experimental paper mill superintendent.

William H. Owens, formerly of American Rock Wool Corp., is now an Engineer with Philip Carey Mfg. Co., Lockland, Ohio.

Charles E. Peterson is now Manager of Quality Control for St. Regis Paper Co., Deferiet, N. Y.

George H. Rand is now Manager of Manufacture for the Northern Division of the International Paper Co., New York, N. Y.

L. V. Subba Rao is now Deputy Manager of the Andhra Paper Mills, Rajahnumdry, India.

Robert W. Reid of the General Printing Ink Co. has been transferred from Kalamazoo, Mich., to Cincinnati, Ohio, as Manager.

Carl-Robert Sahlberg, formerly of Backhammers Bruk A/B, is now Manager of the Liner Board Mill of A/B Statens Skogsindustrier, Lovholmens Bruk, Petea, Sweden.

Homer P. St. Clair, formerly of Beverly Mills Co., is now Superintendent of Steiner Tissue Mills, Gary, Ind.

A. L. Sherwood is now Vice-President of KVP Sutherland Paper Co., Kalamazoo, Mich.

Willard I. Stinger of the Marathon Corp. has been transferred from Rothschild, Wis., to Menasha, Wis., as Supervisor of the Pulp and Paper Section of the Research and Development Division.

Clifton C. Sutton, formerly of General Foods Corp., is now in the Research Laboratories of the Quaker Oats Co., Barrington, Ill.

R. Tourangeau is now Production Manager of the paper division of J. C. Wilson Ltd., Lachute, P. Q., Canada.

Walter H. Vastrick, formerly of the Allied Paper Corp., is now a Sales Representative for the Chemicals, Pigments and Metals Division of the Glidden Co., Baltimore, Md.

Andreas von Koeppen, formerly of the American Boxboard Co., is now Professor of Paper Technology at Western Michigan University, Kalamazoo, Mich.

David R. Wadleigh is now Director of Engineering for Scott Paper Co., Chester, Pa.

Wilmer W. Wagner, Jr., formerly of Eastern Box Co., is now Division Manager of Mead Containers, Baltimore, Md.

Alden H. Webber, formerly of the Bristol Co., is now a Systems Coordinator for Daystrom Control System Division, La Jolla, Calif.

Harry D. Wilder, formerly Student, is now a Research Aide at The Institute of Paper Chemistry, Appleton, Wis.

* * *

Powell River Co., Ltd. is now named MacMillan, Bloedel & Powell River, Ltd., Vancouver, B. C.

Harry E. Earl has succeeded *Clyde Davis* as the corporate representative of Finch, Pruyn & Co., Inc., Glens Falls, N. Y., in the Technical Association.

T. Richard Probst has succeeded *W. A. Wylde* as the corporate representative of Deerfield Glassine Co., Monroe Bridge, Mass.

R. E. Sitzer has succeeded *E. A. Sitzer* as the corporate representative in TAPPI of Hurlbut Paper Co., South Lee, Mass.

G. J. J. Haumann has succeeded *J. H. Nellmapius* as corporate representative of Masonite (Africa) Ltd., Estcourt, Natal, South Africa.

* * *

L. J. Cogan has succeeded *Amel R. Meyer* as the official representative of Graver Tank & Mfg. Co., E. Chicago, Ind.

Eleventh

Coating Conference

TAPPI

Edgewater Beach Hotel

Chicago, Ill.

May 23–25, 1960

INDUSTRY NOTES

North American

Statistics*

Paper and Paperboard Production

Production of paper and paperboard in the first 11 months of 1959 totaled an estimated 31.4 million tons, to mark an 11% gain over the corresponding 1958 figure. Paper production, at 13.7 million tons, and paperboard production, at 14.6 million tons, were each 11% above their respective 1958 total. Output of building paper and board rose by 14% during this period. Preliminary data for December indicate that paper and paperboard production in 1959 will total 34.0 million tons, 10% above the 1958 total and 8% above the previous high established in 1956.

Paper and Paperboard—1959

Production of paper and paperboard in the first three quarters of 1959 was at an annual rate of about 34 million tons, 12% above the comparable 1958 figure. Total 1959 production will probably be close to this 34 million tons, and thus show an 11% increase over 1958. This figure may properly be compared with the gain in the total output of goods and services in the United States as measured by the gross national product as paper and paperboard are essential commodities in virtually every business activity in America. Gross national product will probably average out about 9% above the 1958 level, but about 1% of this gain will reflect the effect of price increases. The paper and paperboard industry is thus showing stronger gain than the economy as a whole. Within the industry, it appears that paper production in 1959 showed a somewhat smaller gain than paperboard production, while the largest percentage gain was in output of construction paper and board. Despite these variations in growth, production of paper, paperboard, and construction, paper and board has each reached a new all time high in 1959.

A new high was also established in the pulp sector of the industry. Total domestic wood pulp production is estimated at 24 million tons for 1959, up 11% from the 1958 rate. Market wood pulp supply also showed a strong gain, partly as a result of the large percentage increase in overseas imports. Domestic market wood pulp output showed a 10% increase. Wastepaper was up about 7% over 1958.

The high output rates have been matched by the gain in dollar sales in the paper and allied products industry (includes paper, paperboard, and converted products). Sales of paper and allied products in 1959 were in excess of $12 billion, compared to $11.0 billion in 1958 and $10.8 billion in 1957. The gain in sales of paper and allied products reflected both the increase in production and the 1% gain in prices of these goods as reported by the Bureau of Labor Statistics.

The increase in dollar sales of paper and allied products has acted to bring the rate of profits back to the levels reached in 1956. Profits after taxes of the corporations in the industry in the first three quarters of 1959 (the latest available data) amounted to 5.2% of sales. For 1959 as a whole the return on sales in the paper and allied products industry was probably about close to this rate. The 1956 profit total amounted to 6.4% of sales.

The record rates of paper and paperboard production in 1959 were achieved with a moderate increase in the number of production workers, as a result of a major increase in productivity. This productivity gain was achieved through a sizable expenditure of funds. The paper and allied products industry spent about $5 billion in new plant and equipment in the 1949–58 period, to which should be added the $638 million spent in 1959. These expenditures resulted not only in the increase in productivity noted above, but also resulted in a 57% increase in paper and paperboard capacity and a 96% increase in the capacity to produce wood pulp.

Behind all these gains in the performance of the paper and paperboard industry in the United States was a strong uptrend in paper and paperboard consumption. On a per capita basis, consumption of paper and paperboard has been moving a little faster than gross national product, adjusted for price change, in the years since the end of World War II. The various sectors of the industry have, however, shown somewhat different growth patterns. If, for the sake of convenience, the industry is divided into four groups (newsprint, printing and fine papers, other papers, boards), the following applies. Of the four, only consumption of newsprint has failed to move above the high established in 1956. Newsprint supply, per capita, in 1959 appears to have been above the 77 lb. of 1958, but well below the 1956 high of 84 lb. Newsprint supply in 1958 totaled about 7 million tons, about the same as the 1956 high. The prospects for domestic newsprint growth depend primarily on its rate of gain as a supplier to the domestic market. Domestic newsprint production made a new high of 1.9 million tons in 1959, and sufficient capacity is available to permit a further increase in output in 1960.

Production of printing and fine paper in 1959 is estimated at 6.1 million tons, compared to 5.6 million tons in 1958 and 5.9 million in 1957. Printing paper requirements tend to move in line with the volume of total business activity; output in 1959 was probably a little above the rate of final consumption, indicating a mild build-up of inventories in the channels of distribution. On a per capita basis supply of these grades in 1959 reached 69 lb. compared to 64 lb. in 1958 and 70 lb. in 1956.

Output of other papers (which include coarse papers, sanitary and other tissue papers, special industrial papers, absorbent papers and building papers) is estimated at a new high of 8.2 million tons. The strongest growth among these grades from 1958 to 1959 has been observed in coarse and special industrial papers, which had fallen sharply in 1958. The group as a whole, however, has been moving a little behind the total economy during the past 3 years. Per capita supply of these grades was about 90 lb. in 1959 compared to 85 lb. in 1958 and 93 lb. in 1956.

Board requirements (paperboard plus building board) have been moving up faster than total economic output during the postwar period. Containerboard and folding box board have shown particularly strong growth trends, but many of the other grades have also shared this growth. Board output (including building board) in 1959, estimated at 17.8 million tons, is probably a little above the rate of final consumption, indicating a moderate accumulation of inventories in the distribution channels. Total board supply in 1959 is estimated at a record high of 17.7 million tons, which amounts to 200 lb. per capita. This compares to 180 lb. per capita in 1958 and 188 lb. in 1956.

These figures combine to show paper and paperboard supply

* American Paper and Pulp Association, *Monthly Statistical Summary*, January, 1960.

(production plus imports less exports) in 1959 at about 38.5 million tons. This amounts to 435 lb. per capita, 7% above the 1958 level, a shade above the 1956 record of 434 lb. per capita. As in 1956, however, the supply is probably somewhat above the rate of final consumption, although the difference between consumption and supply in 1959 is undoubtedly much smaller than it was in 1956.

The experience of 1958 indicates that the paper and allied products industry has renewed its growth pattern that was interrupted in 1957 and 1958 by the need to adjust to the overproduction of 1956. The new types of paper and paperboard now being developed, and new uses being made of existing types, suggest exciting prospects for the paper and allied products industry in the 1960's.

Pulpwood

Total receipts of pulpwood for the first 10 months of 1959 were 31,586,000 cords, an increase of 2,969,000 cords over receipts for the comparable period of 1958. Domestic receipts were 3,074,000 cords above the year earlier total, while imports declined 105,000 cords. All of the regions showed increases ranging from 4% in the Northeast to 12% in the South Atlantic.

Pulpwood consumption in the first 10 months of 1959 was 32,495,000 cords, an increase of 3,329,000 cords over the same period of 1958. All of the regions showed increases ranging from 3% Northeast to 16% South Atlantic.

Inventories of pulpwood at the end of October were 4,964,000 cords, a decrease of 98,000 cords below September, 1959, and a 1,139,000 cords decline from October last year. All of the regions showed decreases ranging from 13% North Central to 46% South Atlantic.

Wastepaper and Other Fibrous Materials

October wastepaper receipts were 840,000 tons; for the first 10-months of this year they totaled 7,838,000 tons, an increase of 649,000 tons above receipts for the first 10 months of last year.

Wastepaper consumption for October was 815,000 tons; the January–October total was 7,709,000 tons, an increase of 413,000 tons above consumption for the first 10 months in 1958.

Inventories at the end of October were 550,000 tons, an increase of 26,000 tons above September, and 113,000 tons above inventories at the end of October, 1958.

Consumption of total fibrous materials for October was 904,000 tons; the January–October total was 8,585,000 tons, an increase of 1,128,000 tons above consumption for the first 10 months of 1958.

Inventories of total fibrous materials at the end of October were 909,000 tons, 50,000 tons below September, and 130,000 tons above inventories at the end of October, 1958.

Wood Pulp

Production wood pulp for the first 10 months of 1959 was 20,276,000 tons, an increase of 2,431,000 tons above the comparable 1958 total.

Wood pulp consumption in the manufacture of paper and board for the first 10 months of 1958 was 20,999,000 tons, an increase of 2,499,000 tons above consumption for the first 10 months of 1958.

Imports of wood pulp for January–October, 1959, were 2,005,342 tons, an increase of 22% above imports for the first 10 months of last year. Imports for Canada for the first 10 months of 1959 were 1,635,939 tons, an increase of 9% over the comparable period of 1958. Overseas imports for the first 10 months of 1959 were 368,860 tons as compared to 209,416 tons in the first 10 months of 1958.

Exports of wood pulp for the first 10 months of this year were 526,511 tons, as against 417,977 tons exported during the same period last year.

Inventories of wood pulp at paper and board mills at the end of September were 523,000 tons, a decrease of 12,000 tons below inventories at the end of September and 10,000 tons below inventories at the end of October, 1958.

Overseas

Belgium

Great Lakes Carbon to Build Filteraid Plant

Construction of a new plant to produce Dicalite filteraids and mineral fillers for continental and northern European markets is now under way in Ghent, Belgium, according to Walter Gramm, chairman of the board of Great Lakes Carbon Corp. The new plant is scheduled to begin operation during the second quarter of 1960.

A new company, Dicalite Europe Nord, S.A., has been organized in Belgium to handle plant operation and sales. Great Lakes Carbon holds a majority interest in this company through a wholly owned subsidiary, Great Lakes Carbon International, Ltd. A minority interest is held by European stockholders.

Netherlands

Dow Plans Styrene-Butadiene Latex Plant

Plans for construction of a styrene-butadiene latex plant in Rotterdam, The Netherlands, are announced by C. B. Branch, president of Dow Chemical International Limited, S.A.

The plant will be built and operated by Dow's wholly owned Dutch subsidiary, Nederlandsche Dow Maatschappij N.V., at the site of its present terminal and warehousing facilities in the Third Petroleum Harbor at Rotterdam. Investment in the new plant will total more than $7^1/_2$ million Dutch guilders ($2 million).

Completion of the plant is scheduled for early spring of 1961, and its initial annual capacity is expected to be large enough to cover the increasing styrene-butadiene latex requirements of Western Europe.

Sweden

$1,050,000 Contract to Black-Clawson

Hafrestroms Aktiebolag, leading Swedish producer of fine papers, has awarded a $1,050,000 contract to the Black-Clawson Co. for construction of a new magazine and printing paper machine. The 160-in. wide machine will add 30,000 tons per year to the output of the Hafrestroms mill in Haverud, Sweden.

The machine will be engineered and constructed principally at Black-Clawson's British plant.

Paper Manufacturers and Converters

Allied Paper Corp.

Appointment

Ted Kayhard has been appointed manager of engineering for the King, Monarch and Bryant Mill Divisions of the Allied Paper Corp. of Kalamazoo, Mich.

Mr. Kayhard, former Chief Engineer of the Carolina Division of the Riegel Paper Corp., is a mechanical engineering graduate of the Newark College of Engineering, Newark, N. J.

In his new position he will be responsible for the direction of the engineering and maintenance functions of the three Allied divisions.

Banner Fibreboard Co.

15% Increase in Capacity

Banner has completed a plant improvement program which

adds an estimated 15% to its capacity for producing colored linerboard and other specialty paperboard.

Columbia River Paper Co.

Divisions Change Names

The names of the various divisions of Columbia River Paper Co. are now as follows:

Oregon Pulp and Paper Co., Paper Division, Salem, Ore., is now Columbia River Paper Co., Oregon Pulp and Paper Division.

Columbia River Paper Mills, Vancouver, Wash., is now Columbia River Paper Co., Vancouver Division.

Oregon Pulp and Paper Co., Lumber Division, Salem, Ore., is now Columbia River Paper Co., Lumber Division.

These changes will have no effect on the company's policies, management, or ownership.

From Feb. 1, 1960, the Executive Offices of Columbia River Paper Co. will be at 1121 S. W. Salmon St., Portland 5, Ore.

Consolidated Water Power & Paper Co.

Spent Sulfite Liquor to Burn

The Appleton mill of Consolidated Water Power & Paper Co. is stepping up by 47% its capacity for burning spent sulfite liquor with the startup of a new boiler plant.

Construction of the million dollar project began last spring, and one of two new boilers went into operation in December, 1959, with a second scheduled to go on-line in February.

The boiler is designed to burn oil and 20,000 lb. of 55% concentrated spent sulfite liquor per hour. Capacity of the former plant for burning sulfite liquor of this concentration was 13,600 lb. per hour. The other new boiler will burn oil and bark refuse from the company's pulp-making operations.

Crown Zellerbach Corp.

Retirement

Auguste D. Levert, well-known figure in southern pulp and paper circles, retired from active service on Jan. 1, 1960.

Mr. Levert joined the Bogalusa Paper Co. in 1925 following graduation from Louisiana State University in chemical engineering. He advanced with the company and later with Gaylord Container Corp. through various channels as engineer, board mill superintendent, assistant works manager, assistant general superintendent, general superintendent, and as assistant to the resident manager.

Mr. Levert was one of the founders of the Community Chest of which he later became president; he has served as president of the Rotary Club, member of Executive Committee of Bogalusa Community Medical Center, president of Bogalusa Country Club, Inc., and vice-president of the Bogalusa Chamber of Commerce. He is also a director of the Washington Bank and Trust Company, and vice-president of the W. B. Gilbert Insurance Agency and will devote much of his time to the latter activities on retirement.

International Paper Co.

Appointments

Stuart E. Kay, vice-president and a director of International Paper Co., has been named director of research. He has served as manager of manufacturing, Northern Division, since 1936.

Mr. Kay will direct the operation of the company's research laboratories and will have responsibility for all research programs carried on by International Paper. The company has two major research laboratories; one at Glens Falls, N. Y., and one at Mobile, Ala.

George H. Rand, who was named assistant to Mr. Kay in 1959, will become manager of manufacturing of the company's Northern Division.

Continental Can Co.

Expansion in Tyler, Tex.

Continental Can added 83,000 sq. ft. to its corrugated box plant in Tyler, Tex., tripling its original size and its production capacity.

The main addition of the new 85-in. corrugator permits materials to be corrugated in one room of the plant, cut and imprinted in the next, then shipped to customers nearby: 95% of the plant's customers are located within 200 miles of the facility.

Southern Paperboard Merger

The merger of Gair Woodlands Corp. into Southern Paperboard Corp. and the subsequent merger of Southern Paperboard into Continental Can Co. has been announced by Charles B. Stauffacher, executive vice-president of Continental's Robert Gair Paper Products Group.

Both corporations had been operating as wholly owned subsidiaries of Continental Can Co. since June, 1959. Continental had acquired 60% ownership of the corporations when the Robert Gair Co. was merged into Continental in 1956; complete control was accomplished in June, 1959, with the acquiring of the assets of the Fort Wayne Corrugated Paper Co. by Continental.

Appointment

Joseph T. Loomer has become manager of bleached board technical development for Continental Can Co.

Formerly manager of sales development for the Group, Mr. Loomer's new assignment will permit application of his knowledge in the coating and allied machine fields to the program for development of the company's new Augusta, Ga., board mill as well as other operations.

Knowlton Bros.

Plant Modernization Program

A $275,000 plant modernization and expansion program is under way, at Knowlton Bros., Watertown, N. Y., manufacturers of specialty papers for technical and industrial application. Scheduled for completion next spring, the current program follows hard on the heels of a similar $1,000,000 facilities improvement campaign that began in 1952 and was completed in 1957.

Among the plant and facility improvements are the construction of a $100,000 addition to the filtration plant to remove radioactive contaminants from plant process water; of the construction of a 90 × 50 ft. warehouse; a 50% increase of the quality control department; a conveyor system; an automatic process control system; and the installation of chain drives on the saturating department driers.

Radioactive Contaminants Removed

A special, giant filter tank, for removing radioactive contaminants from the company's process water which is drawn from the Black River has been installed by Knowlton Bros., Watertown, N. Y., manufacturers of specialty papers.

Radioactive fallout from atomic and thermonuclear bomb tests, however small, makes it necessary to remove this radioactivity because the special papers used for packaging photographic materials are in prolonged contact with the photosensitive materials—up to 2 years—and defects in the films could result if even the most minute amounts of radioactivity were present in the paper. Knowlton Bros. supplies papers for packaging regular camera roll film, x-ray, and other special films.

Marathon Southern Corp.

Expansion

Marathon's third papermaking machine is scheduled to go

into production by mid-summer of this year.

The new Black-Clawson machine is expected to start producing various weights of paperboard just two years after startup of this plant on the Tombigbee River in western Alabama. The plant is now operating at its 300-ton capacity with a Yankee machine turning out Northern tissue and a versatile fourdrinier turning out a variety of papers. Tissue is converted into retail products for the southern market.

Capacity of Number 3 will be approximately 300 tons of bleached board a day and it will be equipped with a 238-in. wire. Length of this machine is 545 ft. and it is housed in a building 85 ft. wide and 830 ft. long.

Memphis Converting Co.

New York City Office

The company has established a showroom and expanded sales office at Room 561, 200 Fifth Ave., New York City. The company, whose general offices and manufacturing facilities are in Memphis, makes boxed gift and everyday wrapping papers under the "Cleo" and "Thrift-Pak" labels. National sales manager Al Farber will be in charge of the New York office.

Nicolet Paper Corp.

Giant Glassine Supercalender Installed

The largest glassine supercalender ever built will be placed in operation at Nicolet Paper Corp., West DePere, Wis.

Designed and built by Appleton Machine Co., the 147-in. wide, 16 roll "stack" is the third to be installed since 1955, each being larger than its predecessor.

Powered by a 600 hp., Westinghouse d.c. drive, the unit is designed for a maximum operating speed of 1500 f.p.m. The maximum lineal inch nip pressure at the bottom nip will be 4400 lb.

Estimated to weigh in excess of 385,000 lb., the supercalender will be installed and ready for operation early in 1960 and is part of an expansion program which includes a new paper machine and other auxiliary equipment.

Owens-Illinois Glass Co.

Big Island, Va., Paper Machine

A new 170-in. paper machine has begun production at the historic Big Island, Va., plant of Owens-Illinois.

The new installation gives Big Island an immediate daily capacity of 265 tons and a future potential capacity of 380 tons.

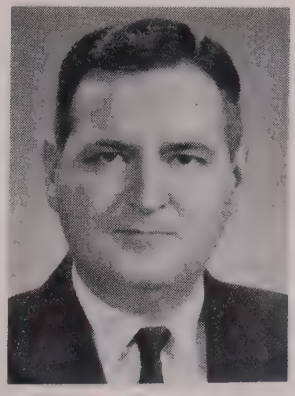
Plastic Shipping Sack this Year

Owens-Illinois Glass Co. a leading manufacturer of glass, plastic and paper products in the packaging field, announced it will begin production this year of a heavy duty plastic shipping sack for industrial and agricultural products.

Manufacture and sales of the polyethylene-based sack will be handled by O-I's Multiwall Bag Division, which produces multiwall paper bags for the shipment of similar products.

Appointment

Paul Gilmore, of Bristol, Pa., and James A. Cobb, of Salisbury, N. C., have been appointed to head the newly created Eastern and South Central Sales Regions of the Owens-Illinois Paper Products Division.



Paul Gilmore

Oxford Paper Co.

Oxford is Sixty

The Oxford Paper Co. is now 60 years old and is entering its 61st year as a corporation. On Dec. 7, 1899, a group of business men, led by Hugh J. Chisholm, The Founder, met at the Falmouth Hotel in Portland to organize a company that would be solely devoted to the production of fine quality papers. Prior to that time the Rumford Falls Paper Co., later to become a part of International Paper Co., was producing newsprint, bag paper, and some writing paper in Rumford, where a new mill for the Oxford Paper Co. would be built.

On December 8, 1899, the Attorney General of the State of Maine certified Oxford as a corporation. The original company was capitalized at $500,000 and the entire amount was subscribed to build the mill on the big bend on the Androscoggin River in Rumford.

In the beginning it was decided to have two paper machines to start. However, early in 1900 it was decided to have four machines with all necessary auxiliary equipment. The work of building the mill was pushed forward in 1900 and 1901 and the first paper machine was started on Dec. 21, 1901. At that time the mill produced 44 tons of paper a day with a few hundred employees. Today the Oxford mill in Rumford produces more than 600 tons a day with 3000 employees.

Packaging Corp. of America

Packaging Hygroscopic Products

A carton sealing process, developed by Packaging Corp. of America, now makes possible the use of single-structure cartons to handle many types of hygroscopic products, thus eliminating the need for inner bags and overwraps.

Called "Calk-Seal," the new process provides low-cost, siftproof, infestationproof carton packaging of such products as cereals, soap powders, spices, potato flakes, milk and dessert powders.

Complete details of Calk-Seal and Calk-Seal Machines are available from Dept. MJ, Packaging Corp. of America, Ohio Boxboard Division, Rittman, Ohio.

Paterson Parchment Paper

Oil Barrier Parchment

For packaging oiled metal parts and other applications involving exposure of paper to grease and oil, Paterson Parchment Bristol, Pa., has introduced Patapar oil barrier parchment.

Designated code number 35-41T, the new material is recommended for industrial applications where extreme oil and grease resistance is an important specification. Patapar oil barrier parchment is said to resist the penetration of oils and solvents and, at the same time, completely stop the normal tendencies of oils to spread along its surface.

Peninsular Paper Co.

"Whiter-Than-White" Twin Tone Cover

Twin Tone Cover, a long-popular Peninsular Paper Co. line, has just been improved with a brighter and whiter color achieved through new brighter pulps and the latest laboratory control techniques. The line will now be referred to as "Whiter-Than-White" Twin Tone Cover. The additional brilliance has been added at no increase in price.

Snoweave Cover and Text line Expanded

Peninsular Paper Co., Ypsilanti, Mich., has expanded their Snoweave Cover and Text line to include five new "Creative

Colors" and fluorescent white. The colors, which were selected by a survey of a scientific sampling of all printers and art directors in the country, are certain muted tints of green, tan, melon, yellow, and blue.

Simpson Timber Co.

Forest Products Laboratory in Washington

Simpson Timber Co. of Seattle announced plans for establishing a forest products research and development laboratory on a 10-acre tract in Overlake Park, near Bellevue, Wash. Groundbreaking will take place this spring with operation planned for late fall.

The laboratory is Simpson's second major building project announced for 1960. Construction of an ultramodern sawmill at Shelton, Wash., began this month.

Laboratory services at Overlake Park will be available to all branches of the 65-year old Simpson Co. in Washington, Oregon, and California.

S & S Corrugated Paper Machinery Co., Inc.

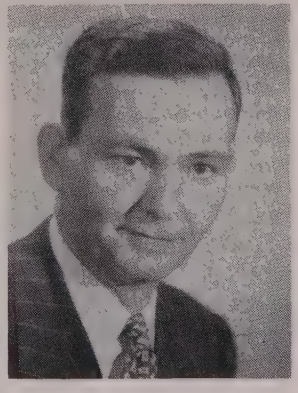
Appointment

August Oberland has been appointed sales representative for S & S Corrugated Paper Machinery Co., Inc., in the west central area.

Mr. Oberland has spent more than 25 years in the corrugated container industry. He has had field experience in the sale and servicing of production machinery, and was the Superintendent of the Elgin Corrugated Box Co., Elgin, Ill., for the past six years. Mr. Oberland will service corrugated container plants in the West Central area, which includes northern and central Illinois, Wisconsin, Minnesota, northern and western Missouri, Kansas, Iowa, Nebraska, North Dakota, and South Dakota, and central Canada.

Mr. Oberland replaces Mr. Richard Lane, who was recently appointed Regional Sales Manager by S & S for the entire Central area. The appointment of Mr. Oberland, and the promotion of Mr. Lane to his newly created position is part of an over-all program by S & S to provide closer customer servicing in the face of the growth of the corrugated container industry. Both gentlemen will make their offices at 720 North Michigan Ave., Chicago, Ill.

S & S Corrugated Paper Machinery Co., Inc., is one of the world's largest manufacturers of machinery for the corrugated container industry. Main offices are in Brooklyn, N. Y., with manufacturing facilities in Brooklyn, and overseas in Haarlem, Holland, and Naples, Italy.



August Oberland

St. Regis Paper Co.

Sherman Paper Products Affiliated

St. Regis Paper has announced that Sherman Paper Products Co. of Newton, Mass., has become affiliated with it through an exchange of stock. Sherman had sales in excess of $12, million in 1959.

Tacoma Sheet Plant on Stream

St. Regis announced that it has commenced production at its new sheet plant at Tacoma, Wash. The sheet is used in the manufacture of corrugated containers. The plant has 70,000 sq. ft. of floor space.

Robert C. Hogeboom has been named sales manager for the new plant, Frank Ward is production manager, and Herbert Carlberg is sales service manager.

Strathmore Paper Co.

Loading Dock Enclosures

Five retractable loading dock enclosures covered with waterproof, neoprene-coated nylon material have solved the problem of loading and unloading paper without spoilage at Strathmore Paper Co., Central Warehouse, Westfield, Mass.

Loading dock with retractable enclosure

Made from Coverlight-N supplied by the Vulcan Rubber Products Division of Reeves Bros., Inc., N. Y., the enclosures are tailor-made, fit snugly around the rear opening of the trucks, and spoilage of paper through weather is thereby practically eliminated.

Educational Institutions

Third Cellulose Conference

A Cellulose Conference will be held at Syracuse on Oct. 27 and 28, 1960. Those who wish to contribute a paper at this Conference are requested to send their application to the Cellulose Research Institute, State University College of Forestry, at Syracuse University, Syracuse 10, N. Y., *as soon as possible*, but not later than May 1, 1960.

Three copies of a 200- to 300-word abstract should reach the Cellulose Research Institute before Aug. 1, 1960. The complete manuscript should be submitted before Oct. 1, 1960.

The subject of the papers must pertain directly or indirectly to cellulose, and must be of a fundamental nature. This means that papers which are concerned merely with technical data for which no scientific background has (yet) been found, will be excluded. A committee will decide whether papers are, on these grounds, acceptable or not. This committee reserves the right to refuse a contribution if it is considered unsuitable.

The contributions will be published in the *Journal of Polymer Science* at the end of 1960 or the beginning of 1961. The Proceedings of the Conference will be available in the form of the Journal's issue.

Packaging Education

The Bernard Baruch School of the City College of New York, 23rd St. and Lexington Ave., will again offer this term a credit course entitled "Industrial Packaging." The course, to be presented in fifteen 2-hour sessions, began in February. The lecturer for this course will be Jerome J. Kipnees, a member of the Packaging Institute and TAPPI. Mr. Kipnees is vice-president-package engineering of Atlantic Gummed Paper Corp., and was formerly vice-president of Container Laboratories Inc.

Maurice A. Burnston, a member of the National Staff of TAPPI, will also serve as a lecturer. Both lecturers have

previously participated in several university packaging courses.

Industrial Wastes Courses

Consecutive courses on industrial wastes will be offered through most of May by the Water Supply and Pollution Control unit of Training Program, Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio.

Graduate chemists and other scientists with backgrounds in water supply and pollution control may enroll for "Organic Industrial Wastes Characterization," May 9–20; "Inorganic Industrial Wastes Characterization," May 23–27, or both courses. No registration, tuition, or other fees are charged for the courses, and text manuals are provided.

Extensive laboratory work and detailed consideration of applications of methods toward the ultimate production of usable water will be emphasized in both courses.

Applications should be addressed to Chief, Training Program, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26, Ohio, or to a PHS Regional Office Director.

Allis-Chalmers Manufacturing Co.

3 1/2-Ton Car Shaker

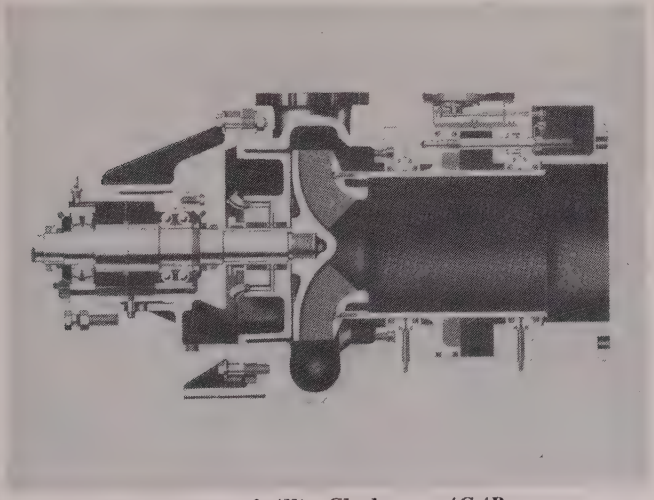
Advantages of Allis-Chalmers 3 1/2-ton car shaker for unloading material from open, hopper-bottom gondola cars, are given in a new leaflet released by the company.

The 3 1/2-ton shaker is specifically designed for plants where unloading of hopper-bottom cars does not warrant installation of Allis-Chalmers 5-ton unit and where smaller capital investment is desirable.

Copies of the leaflet, 26B9438, are available on request from Allis-Chalmers, Milwaukee 1, Wis.

Improved Control for ACAP Pumps

An improved pneumatic control system has been announced by Allis-Chalmers for its adjustable-capacity, adjustable-



Cross section of Allis-Chalmers ACAP pump

pressure (ACAP) pumps. The new system automatically adjusts the cylinder of the single-stage, single-suction pumps in seconds by air pressure, and reduces installation and maintenance costs.

American Instrument Co., Inc.

Constant-Temperature-Humidity Catalog

Environmental test equipment that duplicates global climatic conditions . . . test cabinets large and small . . . baths, ovens, steam-humidity chambers, and bacteriological incubators are among the instruments described in a new catalog published by the American Instrument Co., Inc. of Silver Spring, Md. Hundreds of devices are included, all for the precise control of temperature and humidity in the modern laboratory.

The catalog designated as No. 560, is free on request. It includes 41 pages of illustrations, descriptions, applications, and a temperature conversion chart from °C. to °F., or °F. to °C.

A list of the sales engineering offices located throughout the USA is also included as a ready reference for persons seeking technical assistance in setting up complete systems for conducting tests under controlled humidity and temperatures.

Atlas Copco

Stationary Air Compressors

A new four-page folder describing its stationary air compressor line—including data on its "Twin-Air" rotary screw-type machines which deliver up to 19,400 cu. ft. per min. at 100 p.s.i.—has been published by Atlas, world's largest exclusive producer of air compressors and pneumatic equipment.

Copies are available from Atlas Copco, 545 Fifth Ave., New York 17, N. Y.

Babcock & Wilcox

Denver Office for Boiler Division

Babcock & Wilcox will establish a boiler division district sales office in Denver, Colo.

The new facility will take over steam generating equipment sales and service activities which will be relinquished by The Stearns-Roger Manufacturing Co. on termination of its sales agency agreement with the division on March 1.

Appointed Denver district sales manager is Robert L. Swinney. The new office will be located at 1806 Tower Building, Denver U. S. National Center, 1700 Broadway.

Robert L. Swinney

B-I-F Industries, Inc.

Corrosion Resistant Pump

A new, low-cost, positive displacement pump for concentrated corrosive chemicals is the subject of a new bulletin issued by Proportioneers division of B-I-F Industries.

The diaphragm-type pump, Model 1331 Chem-O-Feeder, is made of corrosion-resistant materials and will efficiently feed such chemicals as 66°Bé. sulfuric acid, sodium hydroxide, caustic soda, phosphoric acid, and plating and photographic solutions. The pump is easily installed, either floor-, shelf-, or wall-mounted, and takes suction directly from the chemical shipping container.

For your copy of bulletin Ref. No. 1331.20–1, write to B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.

Borden Chemical Co.

West Coast Plant Site

The purchase of 26.8 acres of land in Fremont, Calif., to be used as the construction site for its recently announced 90 million pound per year resins and formaldehyde plant, has been announced by Borden.

The new plant will be Borden Chemical's fifth on the West Coast.

Appointment

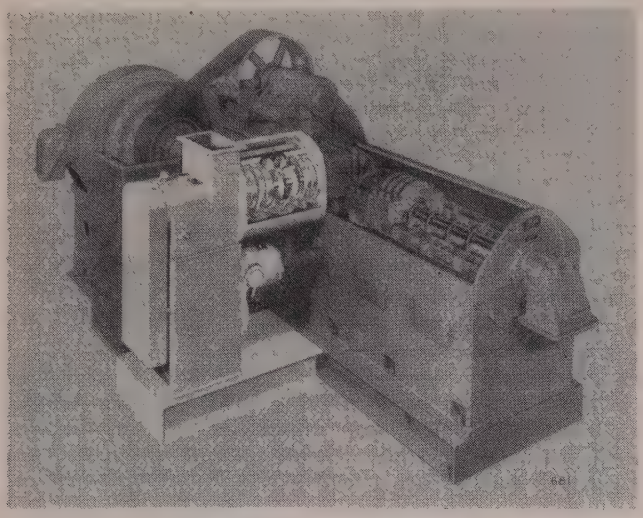
Appointment of George R. Bellue as a sales representative of Borden's Consumer Products Department has been announced by J. A. Wold, general manager.

Mr. Bellue will be responsible for sales of the company's full line of consumers products, including household and home handy-man adhesives and garden products, in Southern California, Arizona, and New Mexico. He will make his office in Redlands, Calif.

Bauer Bros. Co.

New Pressure Feeder

A twin, counter-rotating, intermeshing screw type pressure feeder which greatly increases the capacity and versatility of screw presses has been announced by The Bauer Bros. Co., 1715 Sheridan Ave., Springfield, Ohio.



Bauer pressure feeder

Capable of handling a wide variety of materials, the new feeder can be applied advantageously in many applications in such industries as pulp and paper, chemical, food, and oil seed processing.

Branson Instruments, Inc.

Portable Ultrasonic Thickness Testers

Two portable thickness testers, Audigage* Model 5 and Model 6, are described in an eight-page Bulletin A-200 available from Branson Instruments, Inc. (Stamford, Conn.). These ultrasonic gages permit measurement of thickness from only one side of a wide variety of materials—metal, glass, plastic—by relating a variation in thickness to the change in resonant frequency.

Brooks Rotameter Co.

Corrosive Service Rotameters

Bulletin No. 150, gives details of materials used in manufacturing rotameters for corrosive applications. Various types of meter designs which have been proved in the field are illustrated and described in detail.

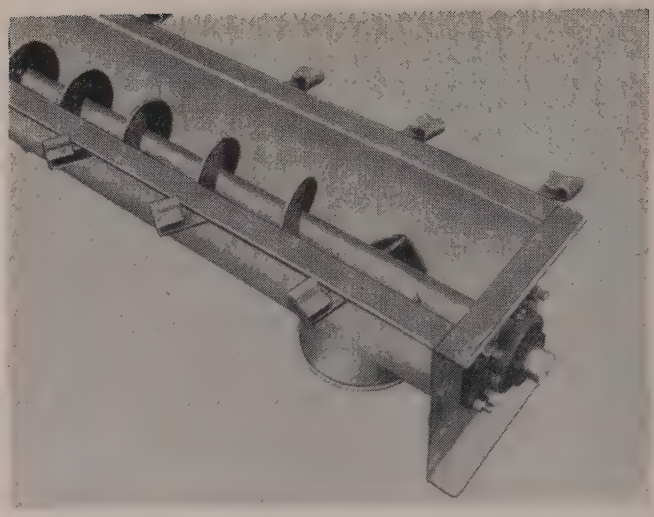
Copies are available from the Brooks Rotameter Co., Hatfield, Pa.

Graphic Rotameter Selector Aid

Bulletin No. 110, shows the full, integrated Brooks line of rotameters. It states the basic advantages of variable area flow meters and displays the various types of meters in their specific areas of application.

Copies are available from the Brooks Rotameter Co., Hatfield, Pa.

* Registered trade mark.



Discharge end of the 9-in. diam. conveyor by the Bucket Elevator Co.

The Bucket Elevator Co.

Conveyors for Chemical, Food, and Pharmaceutical Industries

A new line of stainless steel, helicoid screw conveyors and ribbon flight conveyors with special design features to meet sanitary requirements of chemical and food industries has just been announced by Bucket Elevator Co., Summit, N. J. Conveyors are available in sizes from 4 to 12 in. diam.

Cochrane Corp.

Silica in Boiler Feed Reduced

Desilicizer,* a new commercial process reduces silica in boiler feed make-up to less than 0.5 p.p.m., and eliminates HCO_3 and CO_3 alkalinity.

Particularly suitable for medium pressure boilers (450 to 1100 p.s.i.g.), it can be added to existing zeolite softener systems.

Send for Reprint 124 describing large installation from Cochrane Corp., 17th St. Below Allegheny, Philadelphia, Pa.

Combustion Engineering, Inc.

Sales Representation Terminated

Combustion Engineering, Inc. announced the termination effective Jan. 1, 1960, of its sales agency agreement with T. C. Heyward and Co. of Charlotte, N. C., and Jacksonville, Fla.

Combustion Engineering is establishing district sales offices in Charlotte and Jacksonville to handle sales, installation, and service of steam generating equipment and all other C-E products in the states of Virginia, North Carolina, South Carolina, Georgia, and Florida.

Dean Brothers Pumps, Inc.

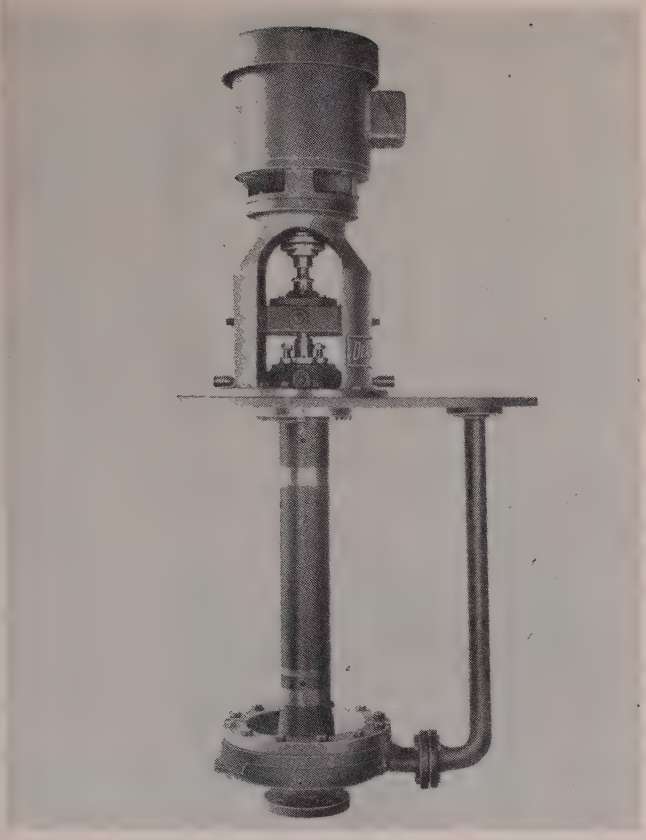
Type pHV Pumps

Supplementing its recently announced line of horizontal centrifugal chemical process pumps, Dean Brothers, Indianapolis, Ind., now offers a companion line of vertical pumps known as Type pHV.

The new line is available in 14 sizes ranging in capacity from 5 to 500 g.p.m. at heads from 10 to 120 ft. and settings from 3 to 16 ft.—inside or outside tank mounted.

As in the horizontal line (Type pH), the new vertical pumps are also available in 17 alloys to meet practically all corrosive acid and caustic applications in a temperature range from −300°F. to +750°F.

* Trademark.



The pHV pump

Additional information is given in Circular No. 219, available from the manufacturer.

Coleman Instruments, Inc.

Automatic Buret Filler

The Coleman Model 27 Autofiller can cut titration time up to 30%. It reduces titration cost by eliminating the need for manual replenishment and adjustment of buret contents to volumetric zero for each titration. After each titration, the operator pushes a button, the titrant flows into the buret and stops automatically when it reaches a sensing probe placed at the zero level. The buret is now filled exactly to the mark and is ready for the next titration.

For complete information on the Model 27 Autofiller, request Bulletin B-256 from Coleman Instruments, Inc., 42 Madison St., Maywood, Ill.

Dyestuff and Chemical Div.—General Aniline & Film Corp.

Solvofen HM

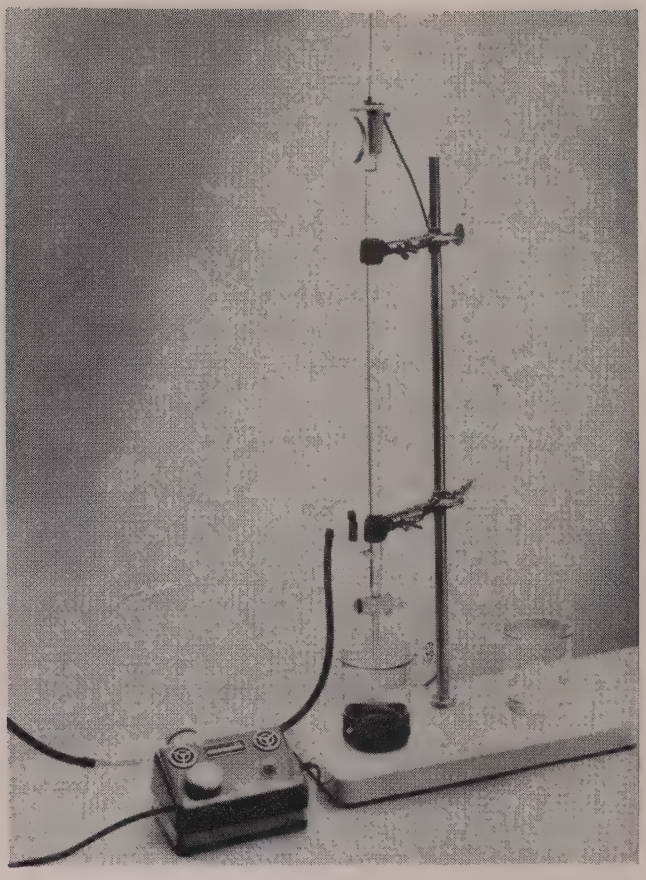
A bulletin describing the properties and applications of Solvofen HM, a dyeing assistant and solvent, has been released by Antara Chemicals, Sales Division of General Aniline & Film Corp.

The brochure lists specific uses in textile applications, both with natural and synthetic fibers, in pasting and dispersing of certain classes of dyestuffs, it describes cleaning procedures involving removal of dyestuffs and pigments from rubber and metal equipment as well as woolen felts. Product data is also given.

E. I. du Pont de Nemours & Co.

"Quilon" Chrome Complex

A new 26-page booklet discussing the use of "Quilon" chrome complex for treating paper products is now being made available by du Pont's Industrial and Biochemicals Department.



The Coleman Instruments, Inc., automatic burette filler

The booklet provides up-to-date information on the application of "Quilon" on corrugator units, its properties in PVA-based release coatings, expanded end-use possibilities, performance data, and complete patent listings.

Copies of the booklet may be ordered from Industrial and Biochemicals Department, D 4012-A, E. I. du Pont de Nemours & Co., Wilmington 98, Del.

Frank W. Egan & Co.

Roll Deflection Chart

Frank W. Egan & Co. of Somerville, N. J., is offering free a slide rule which simplifies the calculation of deflection of rolls under load. Called the "Roll Deflection Chart," the slide rule is particularly useful for determining, under a given load, the deflection of existing rolls made from various materials.

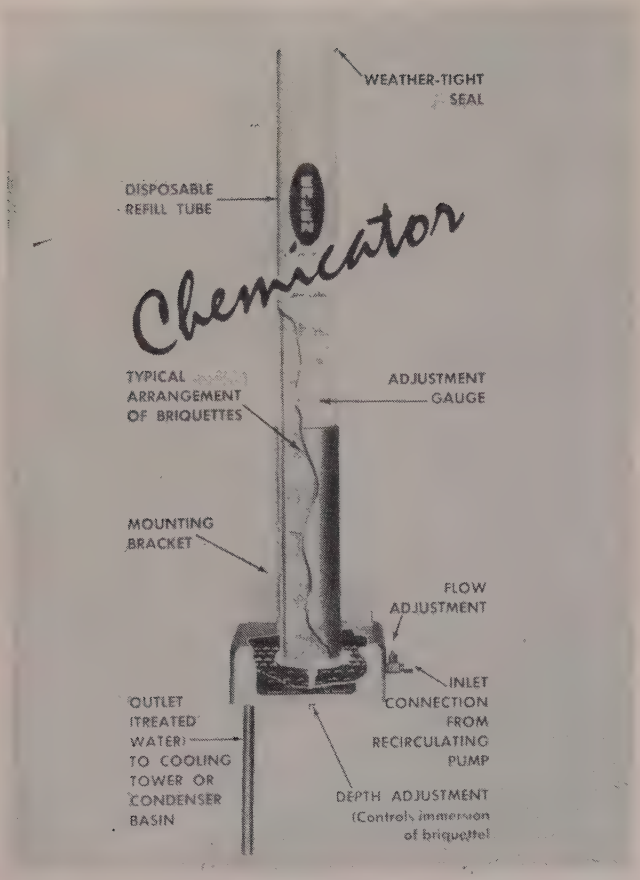
Conversely, the slide rule can be used as a design supplement to compute the proper diameter of a roll for a given condition and for desired maximum deflection. The roll deflection chart is also helpful in determining proper amounts of crown.

Erlen Products Co.

Chemical Control for Circulating Water Systems

The Chemicator, a new concept for feeding balanced chemical treatment into circulating water systems of cooling towers and evaporative condensers, has just been placed on national distribution by the manufacturer, Erlen Products Co., Burbank, Calif.

The Chemicator is a small, lightweight, closed reservoir, mounted on the side of the equipment through which a portion of the recirculating water flows. On the upper portion of the Chemicator a sleeve holds a weather-sealed plastic tube containing a sequence of variously formulated compressed chemical briquettes. These will remove old scale, prevent formation of new scale, reduce corrosion, kill slimes and algae



Erlen Chemicator

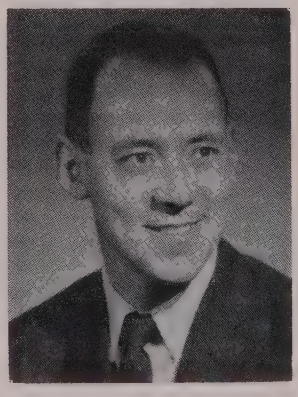
and prevent further growths. Polyphosphates and organic chelates are used; no injurious chromates or phenols. As the briquettes are gravity-fed into the water flowing through the reservoir, they slowly dissolve and are carried into the entire system.

Literature, prices, technical information and installation data may be had by writing to Erlen Products Co., Burbank, Calif.

Diamond National Corp.

Appointment

William J. Duggan has been promoted to manager, Midwest packaging sales. In this capacity he will manage all packaging sales activities in the Chicago, Madison, Minneapolis, and St. Louis offices. Duggan, who will be located in Chicago, will be responsible for the sale of dry carton, carrier, and paraffin products.



William J. Duggan

Dow Chemical Co.

Expansion of Styrene Capacity

A major increase in styrene monomer production capacity is planned.

The new production program will bring Dow capacity to more than 800 million pounds per year. Completion is expected by late 1960 or early 1961.

The capacity expansion involves both the Dow Texas Division at Freeport and the Midland Division at Midland, Mich.

Phenol Plant for Kalama, Wash.

Kalama, Wash., has been selected as the site for Dow's 36 million pound a year phenol plant.

Leland A. Doan, general manager of Dow's Western Division, said that test drilling has been completed on the 150-acre site on the Columbia River, approximately 30 miles north of Vancouver, Wash. Completion of construction is expected in mid-1961.

Texas Polyethylene Expanded

Plans for another major expansion in polyethylene capacity are announced by Dow.

Engineering has begun on new facilities at the company's Texas Division, Freeport, to increase production there by approximately 67%. Completion is expected in 1961.

Exide Industrial Division/The Electric Storage Battery Co.

Data on MP-3 Control Unit

Installation and use of Exide's MP-3 charge control unit, which simplifies daily and equalizing charging of batteries for electric industrial trucks and mine locomotives, are described in a bulletin now available from Exide Industrial Division, The Electric Storage Battery Co., Philadelphia.

This bulletin, Form 5092, may be obtained by writing to the company at Rising Sun and Adams Aves., Philadelphia 20, Pa.

Food Machinery and Chemical Corp.

Chemical Defense Operations

FMC announces the transfer of certain defense research and development programs from its Chemical Divisions' Special Projects Laboratory at a Navy-owned facility in Buffalo, N. Y., to FMC laboratories at Buffalo, N. Y., Baltimore, Md., and Princeton, N. J. Uncertainty concerning the future availability of the Navy building was given as reason for the transfer.

FMC is a primary producer of Dimazine® (unsymmetrical dimethyl hydrazine) and of hydrogen peroxide rocket propellants. In addition, the company is actively engaged in research on the synthesis of high-energy solid fuels.

General Aniline and Film Corp.

Appointments

Three appointments to positions in the newly created corporate Development Department of General Aniline & Film Corp. have been announced by Joseph M. Wilkinson, Jr., director of development.

F. A. Hessel becomes manager of commercial research; W. W. Williams, manager of foreign liaison; and Miss J. M. Moran, senior development specialist.

General Electric

Silicones Guide

A 1960 guide to General Electric's complete line of silicone products is now available in an eight-page illustrated bulletin.

Identified as CDS-129B, this guide also contains information for obtaining additional detailed information on specific silicone products.

Copies of CDS-129B may be obtained from General Electric's Silicone Products Department, Waterford, N. Y.

General Mills, Inc.

Appointment

John Wicklatz has been employed to lead the polymer chemistry department at the General Mills Central Research Laboratories, Minneapolis, Minn.

The Glidden Co.

New Lab Opens

The latest scientific equipment for work with pigments and other inorganic chemicals used by the paper, paint, rubber, and plastics industries is concentrated under one roof in the new Inorganic Research and Development Center dedicated February 3 by the Glidden Co.'s Chemicals Division.

Housed in a new two-story building at Glidden's Adrian Joyce Works, one of the nation's largest titanium dioxide

The new laboratory building, The Glidden Co., Hawkins Point, Baltimore, Md.

manufacturing facilities, the center consolidates research, product development, and technical service facilities previously located in units scattered throughout the country.

"The Glidden Co. believes that one of the most promising potential markets for titanium dioxide lies in the papermaking industry, and this laboratory is equipped with papermaking and coating facilities to develop pigments of superior quality for these end-uses," stated George M. Halsey, Glidden vice-president who directs its Chemicals Division.

In addition to the paper laboratory, the center contains a paint laboratory featuring a complete range of paint making and testing equipment to evaluate pigments for the paint and printing ink industries. The laboratory will also provide finished product control of all titanium dioxide production at the Adrian Joyce Works.

Other departments in the center include a development laboratory, a division research laboratory, a plastics and rubber laboratory, a research library, and an instruments laboratory featuring an electron microscope, various types of x-ray apparatus, and spectroscopic analysis equipment.

Herbert L. Rhodes is manager of the new Inorganic Research and Development Center. Other laboratory executives include: A. C. Dreshfield, director of paper research; C. A. Tanner, Jr., director of development; Dr. Reuben Roseman, director of research; Richard W. Dye, supervisor of the instrument laboratory and the plastics and rubber laboratory, and George B. Taylor, director of the paint service laboratory.

Glidden executives present, in addition to Mr. Halsey and the laboratory heads, included George S. Warner, vice-president-operations of the company's Chemicals Division; Ralph B. Quelos, general sales manager of the division; E. W. Cooper, manager of the Adrian Joyce Works, and W. K. Kelley, manager of the division's cadmium, pigment, and lithopone operations.

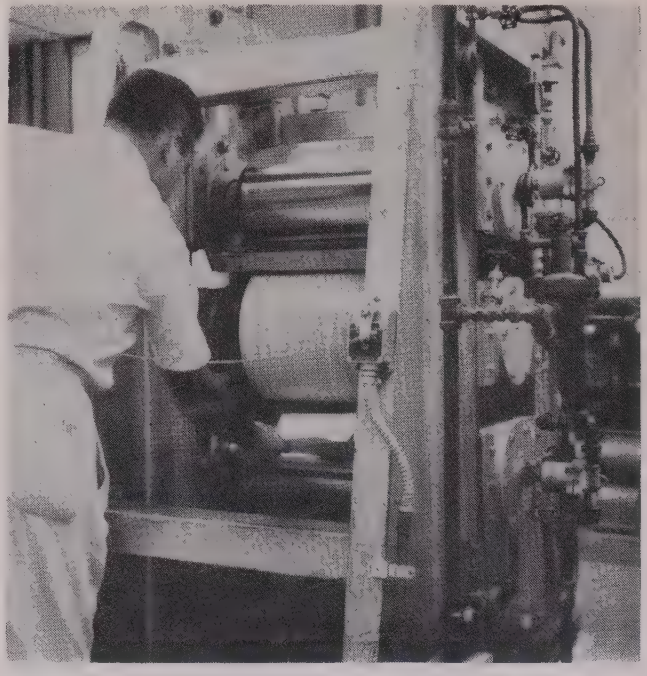
Paper Research and Development Departments

Functions and equipment of the Paper Research and Development Departments new Inorganic Research and Development Center, include the following:

Stock preparation equipment for handsheet making

Functions

1. Fundamental research to develop new information regarding the role of titanium dioxide in papermaking.
2. Applied research to reduce to practical and commercial value of hypotheses and theories formulated as a result of fundamental research.
3. Development work to study broadly the problems associated with the use of titanium dioxide and all papermaking pigments and chemical additives associated with its use.
4. Evaluation of new products.
5. Technical service to any consumer of titanium dioxide in the paper industry who encounters operating difficulties involving titanium dioxide or additives associated with its use.



Handsheet supercalender—with hydraulic loading and steam-heated rolls

Equipment

1. A complete handsheet making system including white water return equipment, Valley beater, Morden slushmaker, Canadian freeness tester, and fiber length classification equipment.
2. For coating preparation, laboratory models of turbo-mixers, Cowles dissolver, Kady mill, and double sigma blade mixers. Recording wattmeters permit studying power consumption related to coating color consistency.
3. Preliminary drawdown bars and rods and laboratory models of air-knife and trailing-blade coaters for applying laboratory coatings to raw stocks. A pilot plant multihead coater is contemplated for future installation.
4. Viscometers, including the Stormer, Brookfield, and Hercules Hi-Shear models.
5. A steam heated, three-roll laboratory supercalender is available for sheet finishing.
6. Automatic starch cooking, protein, and latex adhesive handling equipment is available.
7. A constant humidity room containing instruments for performing standard physical tests including basis weight, caliper, burst, tear, fold, tensile, elongation, stress-strain relations, compression, stiffness, porosity, sizing, smoothness, opacity, brightness, gloss, formation, and dimensional stability.
8. Printing presses, including a Vandercook no. 1 universal power driven, power inked, proof press; a Wisler-Smith rotogravure proof press; an LTF pick tester, and an IGT printability tester.

Goodyear Tire and Rubber Co.

Low Cost Nylon Cord Tire

A low cost tire with nylon cord was introduced in the auto tire replacement market in February by The Goodyear Tire & Rubber Co.

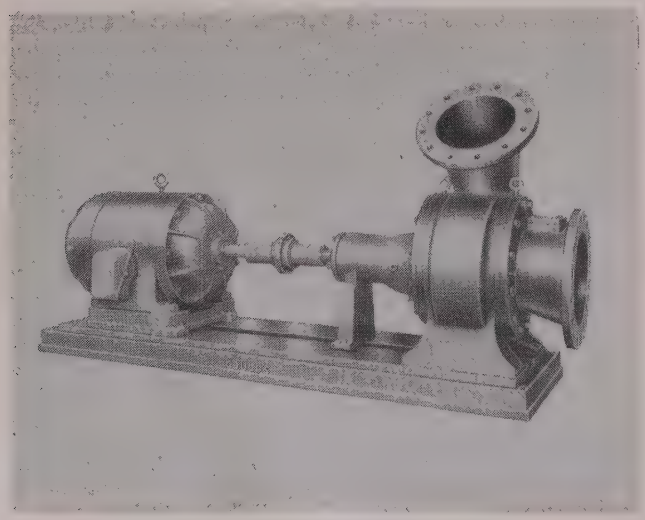
This makes Goodyear the first major tire producer to put the safety and high speed performance of nylon tires within reach of the most economy-minded motorist.

Prices on the new tire, the "3-T Nylon All-Weather," start at $13.95 with a retreadable tire trade-in.

Goulds Pumps, Inc.

Heavy-Duty Solids Handling Pumps

Goulds announces the availability of a broad line of heavy-duty process pumps with a capacity range up to 9500 g.p.m. and for heads up to 220 ft. The pumps are especially adapted for handling (1) fluids with fibrous, granular, or other type solids in suspension whether abrasive or nonabrasive, (2) thick liquids of all types such as paper stock, starches, slimes, slurries, (3) under operating conditions where temperatures up to 350°F. and working pressures up to 400 lb. are encountered.



Heavy-duty solids handling pump

Complete information including performance data, dimensions, etc. can be obtained by writing Goulds Pumps, Inc., 200 Black Brook Rd., Seneca Falls, N. Y., and asking for Bulletin No. 725.5.

Great Lakes Carbon Corp.

Filler and Filteraid Fact Sheet

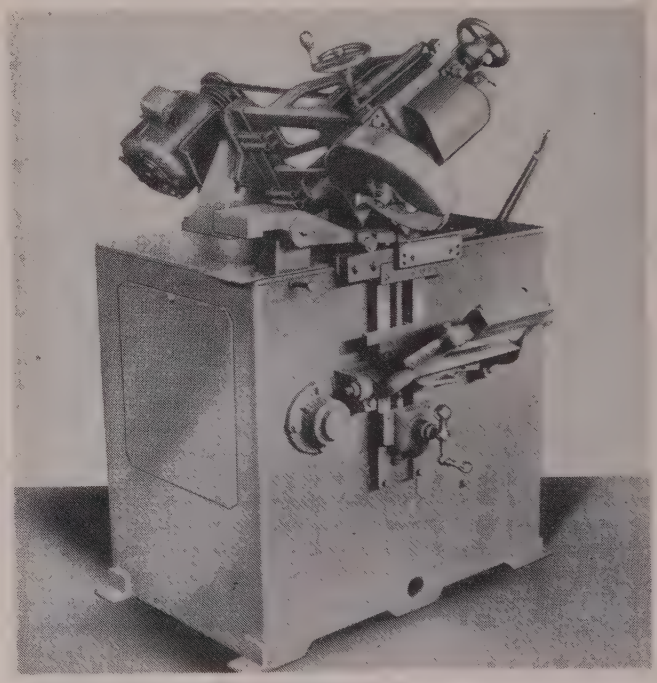
The Dicalite Department of Great Lakes Corp. has issued a two-page sheet entitled "Facts on Filteraids and Fillers." It describes diatomite and perlite fillers and filteraids, the use of diatomite as insulation and diatomite-asbestos and carbon-based filteraids. A graphic table permits quick and ready comparison of the various types in terms of specific gravity, particle size, color, moisture absorption, and other factors.

Copies are available without charge from the Dicalite Department of Great Lakes Carbon Corp., 612 So. Flower St., Los Angeles 17, Calif.

Hanchett Mfg. Co.

Band Saw Grinders

The new Series "A" band saw grinding machines recently placed on the market by Hanchett Manufacturing Co., Big Rapids, Mich., are now available with attachments for full universal saw sharpening applications. The new attachments consist of a continuously variable lift adjusting mechanism and a continuously variable feed adjusting mechanism. These variable adjustments are controlled by means of handwheels and the adjustments may be made with the machines in operation. For complete information write to Hanchett Manufacturing Co., Big Rapids, Mich.; 5727 S. W. Macadam Ave., Portland 1, Ore.; or 3100 Fifth Ave. South, Birmingham 5, Ala.

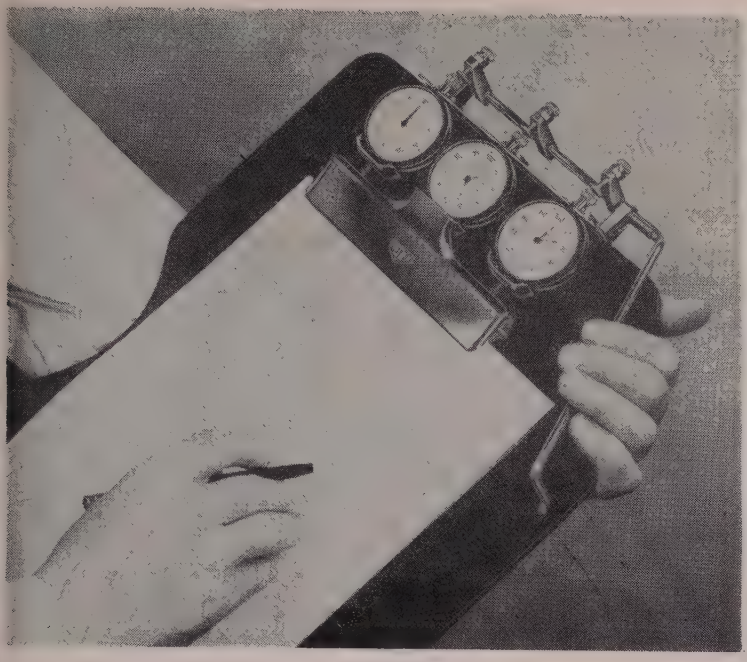


No. A 220 automatic hand saw sharpener

Heuer Timer Corp.

High-Precision Sequence Timing

A sequence timing board for actuating three stopwatches simultaneously with a simple squeeze of the hand, is an-



Sequence timing board

nounced by Heuer Timer Corp., 441 Lexington Ave., New York, N. Y. Based on a design devised and widely used by professional time-and-motion experts to collect "standard data," and called the Multi-Sequence Board, the apparatus is finding new applications in: (a) laboratory research, (b) field action-studies, (c) process control, (d) materials handling, (e) production timing, (f) traffic analyses, and (g) many other classes of scientific, engineering, logistic, medical, and sociological work. It is ideal for TV and radio programming and race timing.

Hooker Chemical Corp.

$10-Million Expansion of Chlor-Alkali Capacity

To increase production capacity of caustic soda, caustic potash, and chlorine at its Niagara Falls, N. Y., plant, Hooker plans to invest about $10-million in a new installation of Hoechst-Uhde mercury-type electrolytic cells during 1960–61.

The cell installation should be completed by the late spring of 1961, soon after first power is expected from the nation's largest power development, the Niagara Project of the Power Authority of the State of New York.

Huyck Felt Co.

Appointment

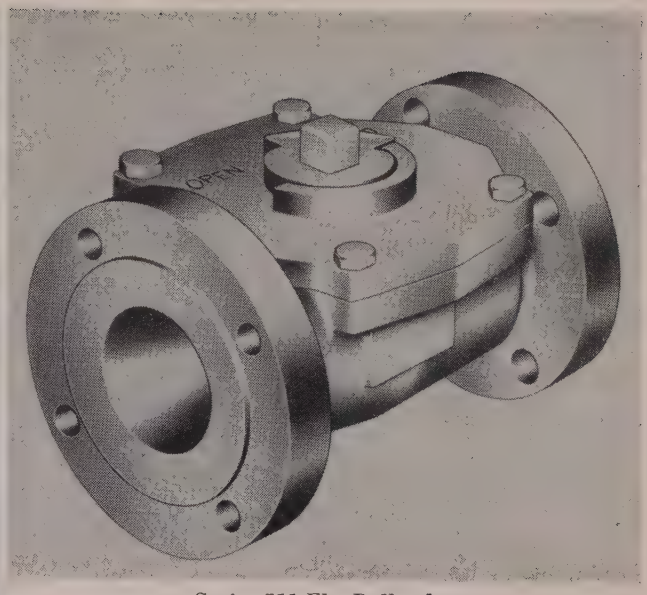
Paul G. Mansuy has been appointed sales manager in charge of the nationwide sales force of the Huyck Felt Co., a Division of Huyck Corp., formerly F. C. Huyck & Sons. Mr. Mansuy succeeds Arthur S. Hayeslip, who recently became vice-president in charge of sales.

Paul G. Mansuy

Hydromatics, Inc.

Fixed Bearing Flo·Ball Valve

Series 711 of Flo·Ball valves, featuring the ball mounted in fixed bearings, and easy servicing without removal from the line, is now available in sizes ranging from 1 to 10 inches for off-the-shelf delivery to industrial users.



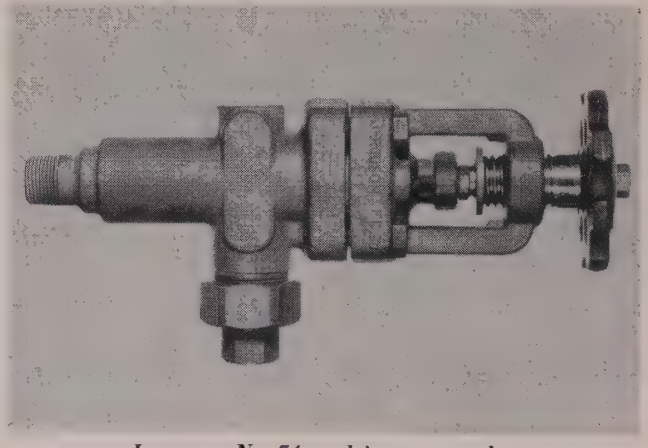
Series 711 Flo·Ball valve

Jerguson Gage & Valve Co.

All-Purpose Angle Valve

A new angle valve which doubles for both liquid level gaging and instrument piping and general use is announced by Jerguson Gage & Valve Co. The Jerguson No. 74 valve combines features which prevent freezing and eliminate problems of wear from galling in one valve unit built with a minimum of parts.

Valve No. 74 serves as a basic liquid level gage valve;



Jerguson No. 74 multipurpose valve

with the addition of a special pipe plug with integral bleed fitting it becomes instrument valve No. 74G which eliminates multiple connections in instrument and general use. For complete details write Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

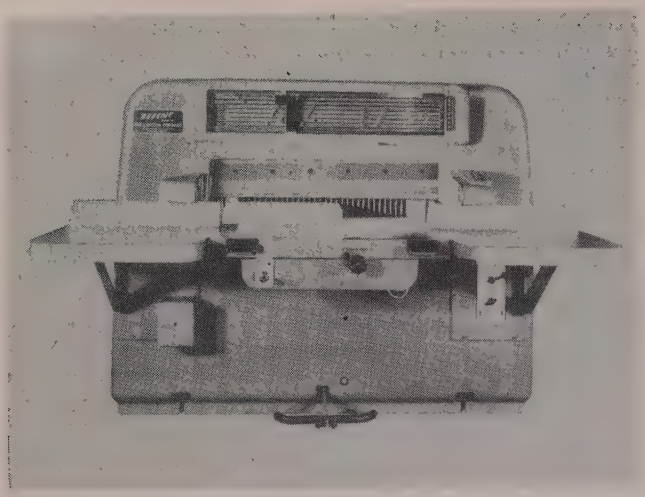
The Lawson Co., Division of Miehle-Goss-Dexter, Inc.

New Lawson Cutters

Three new Regent automatic clamp paper cutters ($34^1/_2$, 42, and 52 in.) are currently being introduced by The Lawson Co. According to the announcement by A. E. Peckman, Sales Manager, the new machines feature hydraulic clamping, standard or automatic spacer operation, and are "priced for the economy minded."

All the new Regents offer 42 stroke-a-minute knife speed, with right-to-left knife action. Clamp openings range from $4^1/_2$ in. on the $34^1/_2$ in. cutter through a generous 6 in. on the 52 in. machine.

Additional details are available by writing directly to The Lawson Co., 2011 Hastings St., Chicago 8, Ill.

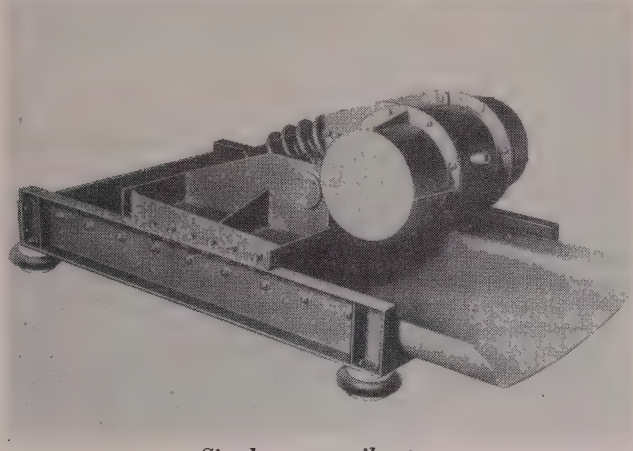


The Lawson Regent automatic clamp paper cutter, series "W"

Link-Belt Co.

Single Motor-Vibrator

Link-Belt's new MC (motorized counterweight) vibrating feeder with single-motor vibrator drive is available for cable suspension or floor mounting to feed a wide range of bulk materials at a uniform rate from bins, hoppers, or other con-

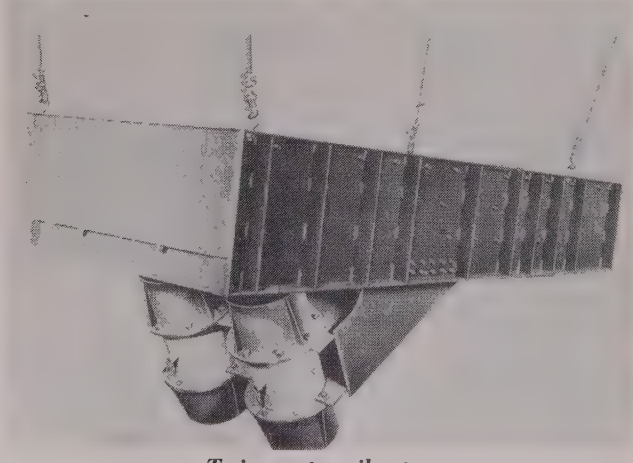


Single motor vibrator

tainers. It evens out surge loads and results in a cleaner installation with considerably less maintenance. Eighteen new single-motor units have been added to the company's extensive line of more than 60 sizes.

Twin Motor-Vibrator

Link-Belt's completely new line of MC (motorized counterweight) vibrating feeders with twin motor vibrator drives can be cable suspended or floor mounted to feed a wide range



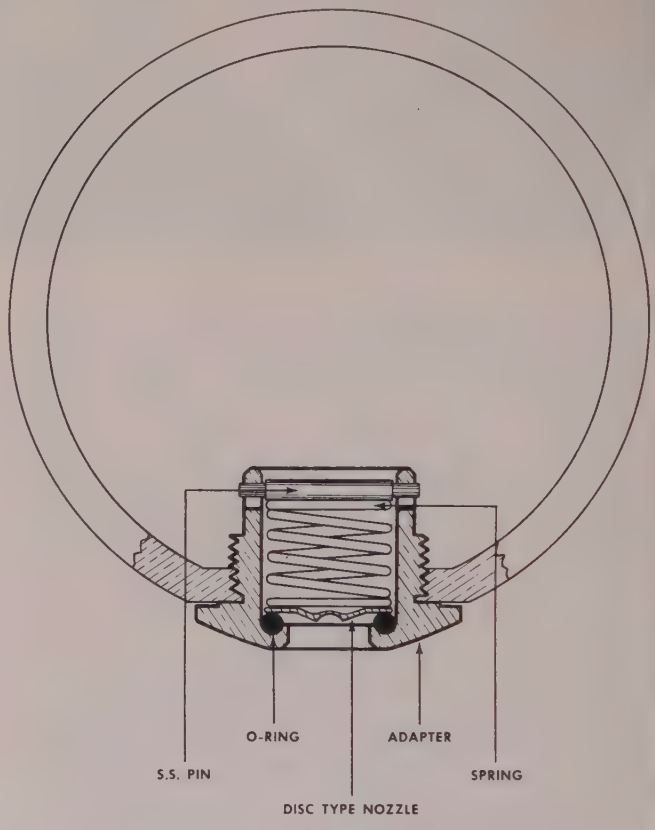
Twin motor vibrator

of bulk materials at tonnages up to 1700 t.p.h. This new line features 31 completely new sizes in feeder lengths from 6 to 14 ft. and trough widths from 1 to 6 ft. Both types are available with special modifications such as feeders with pre-designed hoppers, scalping decks, and live-bottom hoppers.

Lodding Engineering Corp.

Fresh Water Shower

The Econo-Miser, fresh water shower, introduces a new shower-nozzle design and eliminates soldering the nozzles in operating position. Introduced by the Lodding Engineering Corp., Auburn, Mass., the Econo-Miser permits the use of fan, cone, or needle spray. Operation is efficient at all



The Econo-Miser's simple disk-type nozzle design

pressures up to 300 p.s.i. and higher. Nozzle bushings project well inside the pipe to minimize the possibility of foreign particles plugging the orifices. Heavy particles settle at the bottom outside the bushing. Maintenance of the new shower is negligible.

J. E. Lonergan Co.

Silent Hydro-Valve

A new bulletin released by J. E. Lonergan describes the company's nonchattering Hydro-Valve line for liquid service.

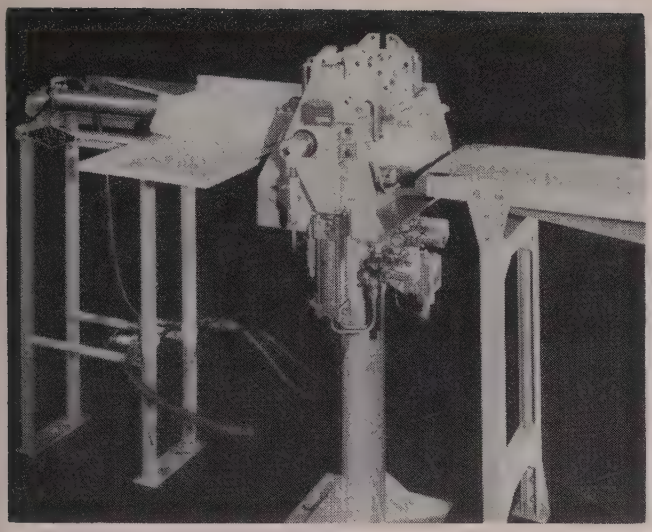
The four-page bulletin gives complete details and specifications on sizes, capacities, materials, and other pertinent data.

A copy of Bulletin L-100/59 may be obtained by writing the advertising department, J. E. Lonergan Co., Second and Race Sts., Philadelphia 6, Pa.

Lamb-Grays Harbor Co., Inc.

New Ream Rotator

A ream rotator which can be incorporated into automated cut-size finishing systems, has been developed by Lamb-Grays Harbor Co., Inc., Hoquiam, Wash., manufacturers of pulp and paper finishing equipment. The ream rotator



The ream Rotator

permits automatic reversal of the sheets before wrapping. Differing orders can now be processed from the same pallet load, with wire or felt side up as required.

Complete details can be had from Lamb-Grays Harbor Co., Inc., P. O. Box 359, Hoquiam, Wash.

Milton Roy Co.

Economical, Accurate Slurry Pump

Bulletin 1158 describes Milton's Oliver Diaphragm slurry pump which is capable of metering slurries with up to 60% solids at a controlled volume accuracy of ±2.0%. Compressed air operation eliminates motor, stuffing box, or leaky packing; no delicate adjustments or high-speed moving parts to wear. Flow volume can be varied from 0 to 180 gal. per hr. at pressures to 90 p.s.i. by remote control electric timer or unique electrical probe mechanism. Details from Milton Roy Co., Philadelphia, Pa.

Mixing Equipment Co., Inc.

Manual on Mill Agitation and Mixing

A new 112-page manual "Agitation and Mixing for Pulp and Paper Mill" has been published by Mixing Equipment Co., Inc., Rochester, N. Y. It is being made available on request to those in the paper industry.

This is the first book of its kind devoted exclusively to agitation and mixing in the mill. It is based on Mixco's 10 years of research into paper technology and on hundreds of installations in mills throughout the country. Many of these installations are illustrated and described in the manual.

Monsanto Chemical Co.

Distributor for Mertone Products

Monsanto announces that Andrews Paper and Chemical Co., Inc., Great Neck, L. I., N. Y., has been appointed sole distributor for Monsanto's Mertone WB-4 and Mertone 200.

The Mertone products are colloidal dispersions of silica in water and are used as a precoat on blueprint and other reproduction papers to obtain clearer, more legible prints.

Mount Hope Machinery Co.

New Plant in Charlotte, N. C.

Construction has started on a new and modern plant for Mount Hope in Charlotte, N. C. It is expected that the company will move from its present Charlotte location to its new plant on Ross Drive in the spring.

This new plant will have complete facilities for the manufacture and servicing of all Mount Hope products and its convenient location in the heart of the southern paper field will greatly expedite new installations and the service of those already in use. It will also house the Mount Hope Southern Sales Office, under the direction of Slaughter Machinery Company of Charlotte.

Nalco Chemical Co.

Appointments

T. M. James has been appointed as field personnel manager of the industrial division of Nalco Chemical Co., Chicago, Ill. Mr. James was formerly manager of the division's Pacific Northwest district, with headquarters at Portland, Ore.

W. V. Cross is being transferred from the Wisconsin district to succeed Mr. James as district manager in Portland, and J. A. Manley will replace Mr. Cross as manager of the Wisconsin district.

National Polychemicals, Inc.

Light Colored Phenolic Resin

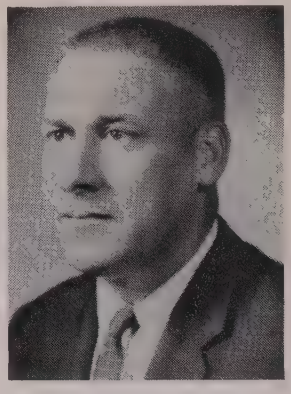
The Plastics Division of National Polychemicals, Wilmington, Mass., has developed POLY-PHEN S-218, phenolic resin based on natural rubber and styrene-butadiene copolymers for use in light colored compounds. The resin is reported to develop a high degree of hardness and stiffness of most molding compounds without increasing the specific gravity of the vulcanizate.

Olin Mathieson Chemical Corp.

Appointment

John Bode has been appointed carton salesman for the Packaging Division of Olin Mathieson Chemical Corp.

Mr. Bode's territory will include northern Indiana, northern Illinois, Wisconsin, Iowa, the Minneapolis-St. Paul area, and Omaha. His headquarters will be in the Olin Mathieson Packaging Division office in the Pure Oil Building, Room 1040, 35 East Wacker Drive, Chicago.



John Bode

OPW-Jordan Corp.

Corrosion Resistance Chart

A new 4-page Corrosion Resistance Chart J-CRC is available from OPW-Jordan. It lists over 150 different chemicals and their recommended usage with ductile iron, iron, steel, 316 and 304 stainless steel, monel, brass, bronze, copper, aluminum, and plastisol plastic. J-CRC also shows which gasket materials are needed for the various chemicals when Kamlok Quick Couplers are used and which O-ring materials are needed when swivel joints are used with these chemicals and compounds. Free Corrosion Resistance Chart available from OPW-Jordan, 6013 Wiehe Road, Cincinnati 13, Ohio.

Philips Electronic Instruments

Booklet Describes Pipe Fluoroscopy

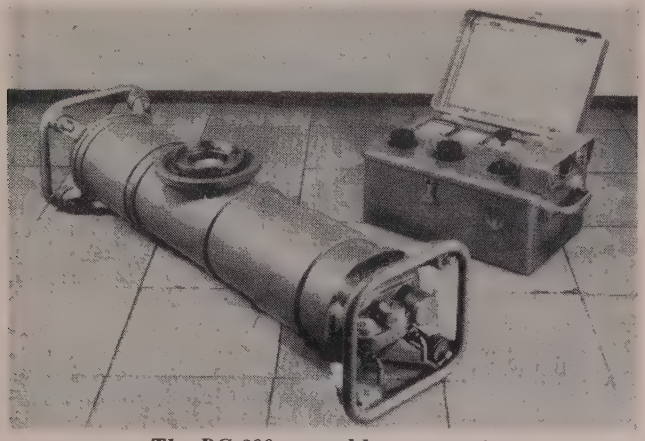
A new 12-page booklet titled "A Progress Report on Continuous Fluoroscopic Inspection of Submerged-Arc Welded Line Pipe" is available from Philips Electronic Instruments, 750 South Fulton Ave., Mount Vernon, N. Y.

The report was prepared by A. B. Wilder and E. B. Henry,

Jr., National Tube Division, U. S. Steel Corporation, Pittsburgh, and was presented at a panel session on Nondestructive Testing at Denver on June 8, 1959.

Portable X-Ray Unit

A portable industrial x-ray unit, the Norelco PG 300, provides high penetrating power and good radiographic definition. Available from Philips Electronic Instruments,



The PG 300, portable x-ray unit

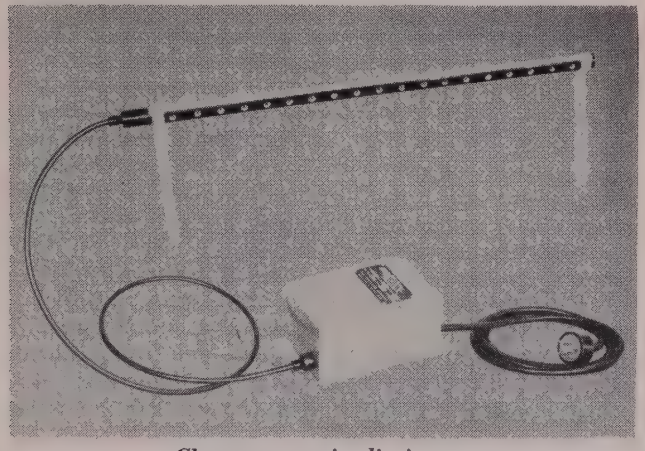
the unit is completely self-contained, shockproofed, rayproofed, and weatherproofed for outdoor operation.

Additional information may be obtained from Philips Electronic Instruments, 750 South Fulton Ave., Mount Vernon, N. Y.

The Portland Co.

Shockless Destaticizer

The "Statomatic," is a completely shockless addition to the Chapman Static Eliminator line manufactured by The Portland Co.



Chapman static eliminator

The unit removes static electricity from paper, plastic, cloth, or other materials where static interferes by disrupting normal operations.

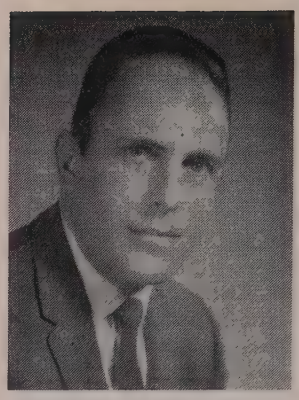
Free literature is available from The Portland Co., 58 Fore St., Portland, Me.

Raybestos-Manhattan, Inc.

Appointments

The Manhattan Rubber Division of Raybestos-Manhattan, Inc., Passaic, N. J., has announced the appointments of M. G. Tolsma and J. V. Getchins as rubber roll specialists.

M. G. Tolsma will cover the area comprising all of Connecticut and Vermont, Southeast New York, Central and Western Massachusetts, and J. V. Getchins will service the rubber roll requirements in the North Jersey area primarily the paper and textile mills.



Mel Tolsma, Raybestos-Manhattan, Inc.

John Getchins, Raybestos-Manhattan, Inc.

Remington Rand

The Tape Searchwriter

A new eight-page booklet, describing in detail the Univac Tape Searchwriter, has just been published by Remington Rand Division of Sperry Rand Corp.

The Tape Searchwriter is an integrated system which provides an economical method for searching a magnetic-tape file for a desired item. When the item is located, the information is automatically typed.

It may also be used as an error-checking interrogator because it incorporates all the error-checking features found in Univac systems. It is transistorized, and is conveniently arranged so that typewriter, operating controls, and tape transport are within easy reach of an operator.

The new unit is designed to operate with the Uniservo II.

Except for tape handler, it is self-contained. Power supplies, read-write amplifiers, control circuits, and tape control are integral.

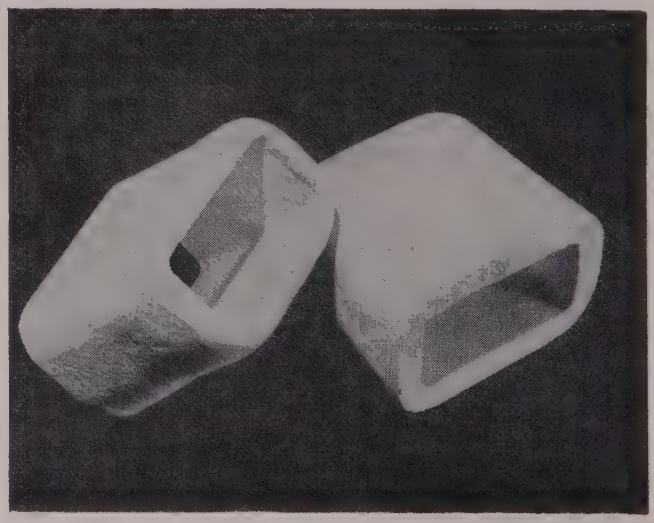
A Synchro-Tape typewriter is included, which permits identification of the desired item manually on the typewriter keyboard or automatically from previously prepared paper tape. When the search is completed and the item located, the typewriter types the information or punches it on paper tape—or both.

A copy of this descriptive booklet can be obtained at any Remington Rand branch office, or by writing to the company at 315 Park Ave. South, New York 10, N. Y., and requesting U 1729.

Resisto Chemical, Inc.

Shaped Fibrous Potassium Titanate

Resisto announces the successful production of complex integral shapes in Resistotherm (a special compact of du



Resistotherm rectangular pipe shapes

Pont's fibrous potassium titanate). Resistotherm is a low density, wide application insulating material exhibiting very low thermal conductivity at temperatures to 2200°F.

For additional information on Resistotherm—or related trowelable materials and high-temperature resin binder formulations—write: W. J. Barrentine, Resisto Chemical, Inc., P. O. Box 1945, Wilmington 99, Del.

Rohm & Haas Co.

New President Elected

Otto Haas, founder and chief executive of Rohm & Haas Co., Philadelphia, chemical manufacturing firm, died at his home on Jan. 2, 1960.

Shortly before his death, Mr. Haas had retired as active head of the company, due to failing health. At a special meeting of the Board of Directors, called at Mr. Haas' request on Dec. 31, 1959, Dr. F. O. Haas, son of the founder, was elected president of the company and chairman of the Executive Committee of the Board.

John C. Haas, also a son of the founder, was elected vice-chairman of the Board, replacing Dr. F. O. Haas in that capacity. Mr. John Haas is also a vice-president of the company and a member of the Executive Committee.

Dr. Ralph Connor was elected chairman of the Board and will continue as a member of the Executive Committee and as vice-president in charge of research of the company.

Roots-Connersville Blower—Division of Dresser Industries Inc.

Rotary Gas Meter for Line Mounting

Employing a new concept in rotary-type positive displacement gas meter design, and aimed at providing accurate metering at lower cost, the 3M125 meter has just been announced by Roots-Connersville. Described as "just a bulge in the line," this new unit can be flange mounted directly in either a horizontal or vertical gas line without need for additional support, and provides straight-through gas flow. A flow range to 3000 cu ft. hr combined with a working pressure rating of 125 p.s.i.g., is intended to adapt this meter to measurement of many industrial and commercial loads for which rotary-type meters have not previously been available.

Additional details, including dimensions and capacity ratings at various metering pressures, are contained in the manufacturer's specification sheet S-RMI-125IM.

Sandvik Steel, Inc.

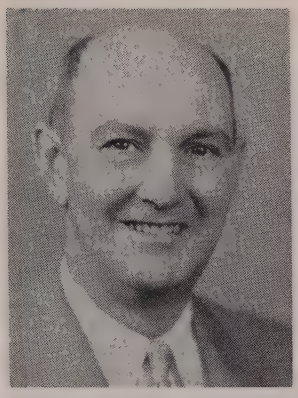
Steel Conveyor Belts

Sandvik Steel, Inc., now offers its steel conveyor belts in widths up to 48 in. The maximum width formerly available was 32 in., although wider belts could be fabricated by longitudinally joining two or more narrower belts.

The belts are available in carbon or stainless steel and are especially trued and flattened at the mill for conveyor application.

Further information may be obtained from Sandvik Steel, Inc., Fair Lawn, N. J.

Sandvik steel conveyor belt



George E. Clink, Sandy Hill Iron and Brass Works

Charles S. Adams, Sandy Hill Iron and Brass Works

The Sandy Hill Iron & Brass Works

Appointments

George E. Clink and Charles S. Adams have been made assistant vice-presidents. Mr. Clink is also serving as a member of TAPPI's subcommittee on paper machine drive requirements.

Floyd H. Rourke, has been named assistant to the president.

Scapa Dryers, Inc.

Appointment

Scapa Dryers, Inc., of Waycross, Ga., announce that Kenneth W. Buchanan has been appointed a director of the board of directors, and vice-president in charge of sales.

Service & Erection Co.

New Insulated Tank

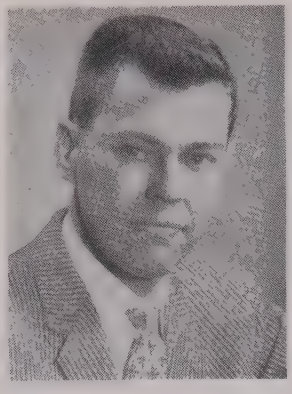
An insulated tank designed specifically for outside storage of pulps, chemicals, and clays has been introduced by Service & Erection Co. Known as the Eskamo, it is constructed of reinforced concrete with acid- and alkalineproof ceramic surfaces both inside and out. All insulation is placed between the walls so that there is no outside insulation and weatherproofing to maintain.

Additional information and price estimates on the Eskamo can be obtained by writing Service & Erection Co., 1673 Washington Road, Pittsburgh 28, Pa.

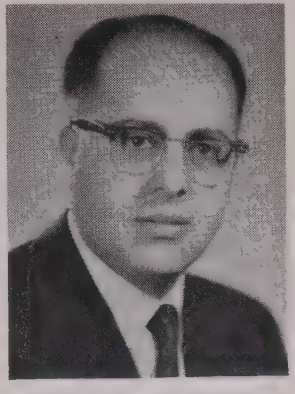
The Smith & Winchester Manufacturing Co.

Appointment

Farhang Javid has been appointed vice-president and General Manager of Smith and Winchester Co., South Windham, Conn., effective January 18. Smith & Winchester has manufactured machinery for the paper industry for the past 132 years.



Floyd H. Rourke, Sandy Hill Iron and Brass Works

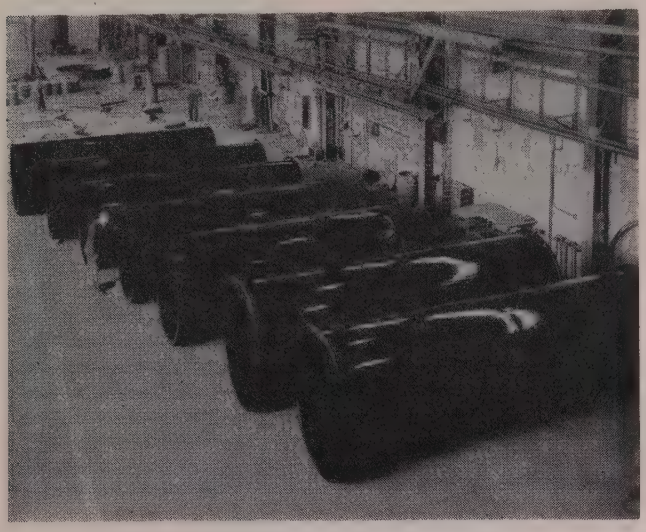


Farhang Javid, Smith & Winchester Mfg. Co.

A. O. Smith Corp.

Colored, Glass-Protected Smokestacks

Steel smokestacks lined, inside and out, with a richly colored acid-resistant glass, developed and pioneered by the A. O. Smith Corp., Milwaukee, Wis., have a three to five times



Glass protected smokestack sections

longer life than ordinary, unlined steel stacks in similar service. A wide variety of custom colors can be permanently fused into the stack's glassed exterior, and weather conditions have little or no dulling effect on the shiny colored glass.

Sprout, Waldron & Co., Inc.

Super Sifter Redesigned

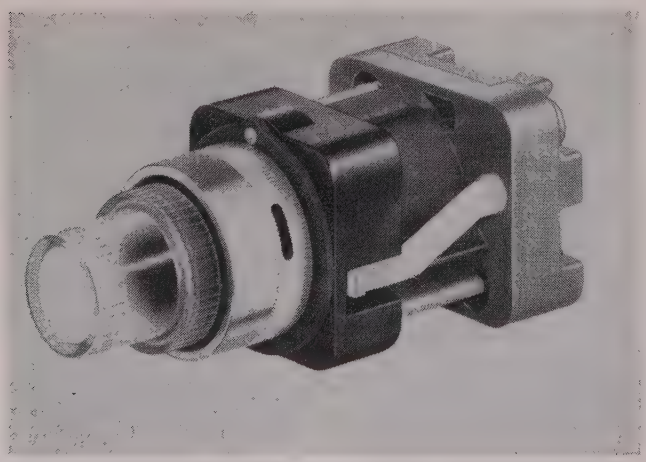
Sprout-Waldron has announced a redesigned sifter for extremely high capacity accurate sifting of dry materials. The new "Super Sifter" design features square, tubular, horizontal cross members in the structural frame. The number of these cross members has been increased permitting the unit to operate under the most severe industrial requirements.

For further information, ask for Advance Specification Sheet No. 216.

Square D Co.

Illuminated Push Button

A new illuminated push button, announced by Square D, saves mounting space and installation time by combining in a single device both a push button and a pilot light. The latest addition to Square D's line of oil-tight control units, the new push button features pressure connectors to eliminate



Illuminated push button

internal wiring. Terminals are clearly marked for easy wiring.

For details, write for Bulletin 9001-T. Address Square D Co., 4041 North Richards St., Milwaukee 12, Wis.

Testing Machines, Inc.

Paper Expansion Testers

TMI now makes available a data sheet illustrating and describing three different types of paper expansion meters.

The principle of the instruments is to show the change in length of a given specimen of paper caused by a change in the relative humidity of the atmosphere surrounding the paper.

For complete information write to Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

Data Sheet

Testing Machines, Inc., has available a data sheet illustrating and describing four different testing machines for paper, paperboard, fiberboard, and wooden shipping cartons and boxes.

Instruments described on this sheet include: Parcel Prover, Vibration Tables, TMI Revolving Drum Tester, and the Papric Dirt Counter.

For complete information write to Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

Texas Gulf Sulphur Co.

$1 Million Filtration Plant at Beaumont

Texas Gulf Sulphur Co. disclosed plans for the construction of a plant for the treating of sulfur by filtration to be located at its Spindletop mine near Beaumont, Tex. The plant is expected to cost about $1,000,000. It will operate in connection with nearby shipping facilities at the company's new Neches River Terminal.

A contract for the construction of the plant has been awarded to Consolidated Western Steel Division of the United States Steel Corp. Construction is due to begin about March 1 and completion of the new plant is scheduled for midsummer of 1960.

Thwing-Albert Instrument Co.

Appointments

John Fachet has been elected as vice-president, manufacturing; Ralph E. Green, vice-president, technical sales and quality control; and Charles A. Paul, Jr., as secretary of the Thwing-Albert Instrument Co., Philadelphia.

Torit Manufacturing Co.

Small Dust Collector

A compact, low-cost industrial dust collector suitable for use in any light dust-producing operation is being produced by Torit, St. Paul manufacturer of dust collectors and associated equipment.

Model 301 stands only $21\frac{1}{2}$ in. high and occupies a space 12×14 in.

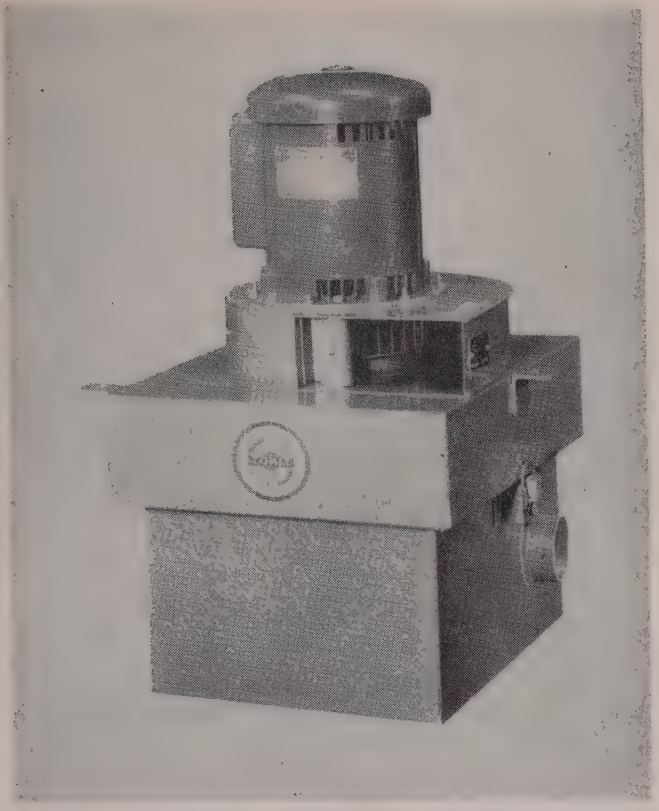
For additional information on the Model 301, write Torit Manufacturing Co., 1133 Rankin St., St. Paul, Minn.

Union Carbide Plastics Co.

Polyethylene Paper Coating

A new high-density polyethylene extrusion coating compound by Union Carbide Plastics Co., designated DGDD-7401 Natural, cuts in half the coating weights required to give paper excellent impermeability to moisture, grease, and oils.

DGDD-7401 Natural can be extruded onto paper at good commercial speeds in coating weights as low as 6 lb. per ream. Formerly, 20 lb. per ream was the lowest practical coating weight possible with high-density polyethylene.



Model 301 dust collector

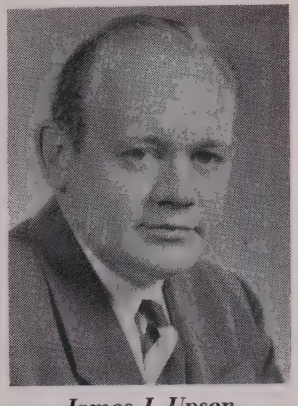
The Upson Co.

Fiftieth Anniversary

A half century of notable achievement and outstanding progress and development is being observed throughout 1960 as The Upson Co. of Lockport, N. Y., largest manufacturer of laminated wood fiber panels under one roof, in the world, celebrates its 50th anniversary.

The span of years between 1910 and 1960 constitutes a golden era in the annals of a company which had its modest beginnings in three small buildings with 16,000 sq. ft. of floor space in the east end of the Niagara County seat.

Today the huge Upson plant and offices in the west end of Lockport spread over 23 acres on which there are 50 buildings with over 300,000 sq. ft. of floor space.



James J. Upson

To inaugurate the golden anniversary program of accelerated activities and promotions, Upson's large force of division sales managers and district managers, whose territories cover every state in the continental United States, was brought to the Lockport headquarters in January. This was the first national sales meeting held in Lockport since 1925 and was the biggest and most successful ever planned.

President James J. Upson welcomed the sales representatives. Climaxing the 50th anniversary banquet was his presentation of the President's Trophy to "the outstanding sales manager of the year," William W. Suttle, who heads the Western Division and has his headquarters in Prairie Village, Kansas. Mr. Suttle has been with Upson since Oct. 1, 1941, and has served as sales manager of the Southern and Central Divisions.

R. T. Vanderbilt Co.

Appointment

Robert W. Shaw is now in charge of R. T. Vanderbilt's Kalamazoo office located at 125 West Walnut St. and their Midwest territory (Michigan, Wisconsin, Minnesota, and Western Ontario). He is replacing Donald A. Hughes who will return to the East Norwalk, Conn., laboratories in charge of a new research program.

T. B. Wood's Sons Co.

Ultra-V Drives

Bulletin No. 9102, "Wood's Ultra-V Drives," gives 36 pages of useful information on a drive said to reduce over-all drive dimensions by as much as 50%, save up to 25% in weight and save up to 30% in cost over conventional V-belt drives.

Details from T. B. Wood's Sons Co., Chambersburg, Pa.

Young Machinery Co., Inc.

Robinson Mfg. Purchased

Henry T. Young, president of The Young Machinery Co., Inc., announces the acquisition of the entire plant and manufacturing facilities of the Robinson Manufacturing Co. whose plant is located in Muncy, Pa.

The Young Machinery Co., Inc., whose present plant is located in Pennsdale, near Muncy, Pa., was founded in 1947 and has been engaged in manufacturing materials handling, pneumatic conveying and mixing systems for use in the chemical, pulp and paper, feed and flour, plastics and many other industries.

The Robinson Manufacturing Co. was founded in 1900 and has been manufacturing a similar but additional line of equipment.

General

Liquid Tote Tanks

With a pioneering eye on the future and with the thought in mind of capturing more of the large and northwest market for adhesives and resins, where they are major manufacturers, Borden Chemical Co., early in 1956, tested a 300-gallon, portable liquid container for the intra- and interplant handling of various liquid products shipped from Springfield, Ore., Kent, Wash., and Los Angeles, Calif. A test program handling urea formaldehyde shipped to the wood industry, now centered near Springfield, Ore., was put in motion at the Oregon plant.

Borden rented a tote tank, the 300-gallon container now in extensive use at their west and northwest facilities, for a six-month period to ascertain the feasibility of such handling of liquid adhesives and resins. Tests first were conducted at the Borden Springfield plant, then at the customer plant. The lumber industry customer was so pleased with the operation, Borden found it difficult to get the bin back and get the overall bulk handling operation into motion.

As a result of this experimentation with the new container, Borden made a few design suggestions regarding its use for resins and adhesives to Tote System, Inc., Beatrice, Neb., engineers and fabricators of the portable drum, and manufacturers of the tote system of dry bulk material handling, centered around the tote bin, now in international use throughout the industrial world.

These changes included:

1. Valve changed to elbow valved and equipped with separate shutoff. All brass equipment was specified for fittings to avoid metallic color contamination of waterwhite urea. (Now, all fittings are being re-converted to aluminum.)
2. A special angle was welded on tote tank near valve to protect against possible fork truck damage.

Filling tote bins at Springfield, Ore., plant. Tank holds 300 gal.

3. Top closure size increased to that of standard drums, allowing full accessibility for cleanout of sticky material.
4. Included top vent plug to enable full flowout without necessity of removing top.

These changes were made and, in September, 1956, Borden began its program of liquid handling in tote tanks. The company now is discussing further expansion of the operation with the Nebraska manufacturer.

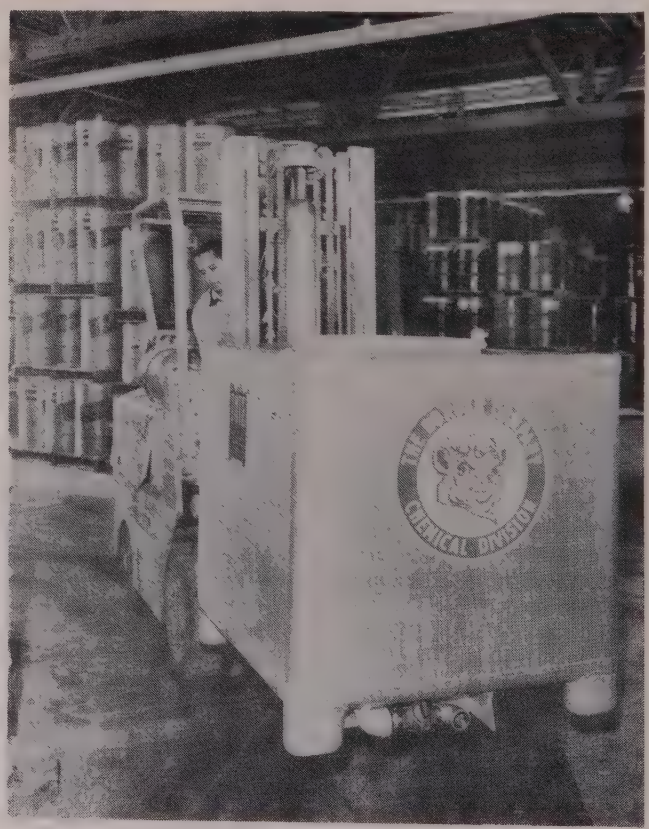
The customer benefits of the tote tank, which holds the equivalent of six 55-gallon drums, are:

1. Single handling by fork truck from dock to point of use.
2. Space savings in plants where space is a premium.
3. Increase in product purity assurance. Ferrous metal contact with urea could contaminate the product (discoloring is of particular concern in edge gluing). The all-aluminum tote tank and brass spigot (which will be replaced by aluminum on all bins within a few months), make such contamination impossible.
4. Production operations vastly improved. One mechanical movement of bin takes the place of rolling six drums by hand.
5. The loss of drum resale by customer is more than offset by the benefits accrued in inplant handling, product purity, and improved morale and safety.
6. Operator can be used to better advantage at his machine.
7. Safety factor. Lifting problems are no longer presented. No chance of sprain, etc., in mechanical handling setup.
8. Stick measurement allows ease of inventory control of resins.

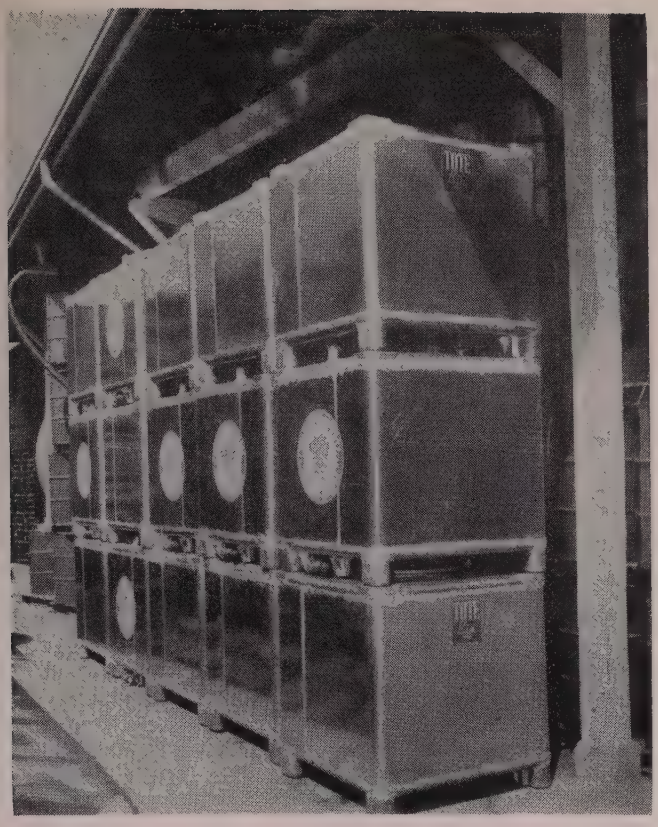
The following bulletins were circulated by Borden to their customers citing the tote bin benefits:

Resins and glues are filtered as they are filled into tote tanks

Opening for access to bin for cleanout; At left is vent for full flowout without removing cover



Tote tanks are easily transported by fork-lift



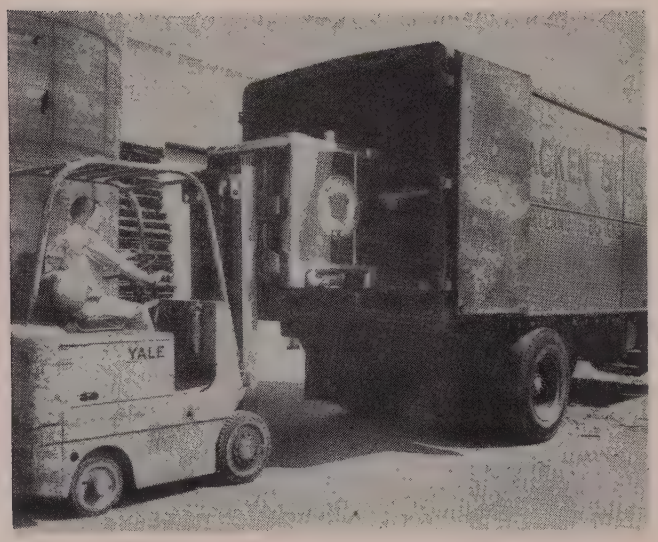
Tote tanks tiered to save up to 60% of warehouse space

Liquid Adhesives

Borden proudly pioneers the introduction of portable tanks liquid adhesives.

The use of tote bins for liquid adhesive shipping is intended to reduce material handling and provide for a more flexible supply of resin in our customer mills. A tote bin holds more adhesive and occupies less space than 55-gallon drums. A full supply of adhesive can be stored at the point of use in a container that can be drawn from by simply opening a valve. Tote bins are constructed of light but strong aluminum.

Tote bins are equipped with $1^1/_4$-in. bottom outlet, and a 2-in. 'bung' opening on the top for 'stick' gauging, and a 22-in. manhole on the top for cleaning. The bottom outlet is sealed by a plug valve. It is recommended that a $1^1/_4$-in. gate valve be installed on the bottom outlet by the customer to control the resin flow as it is drawn from the tote bin. It



Tote tanks being placed on flatbed conveyance

is also suggested that the tote bin be rinsed with cold water immediately after emptying.

When empty, the tote bins are to be returned by the delivering carrier, *collect*, to the Borden Co., Chemical Division, at the original point of shipment

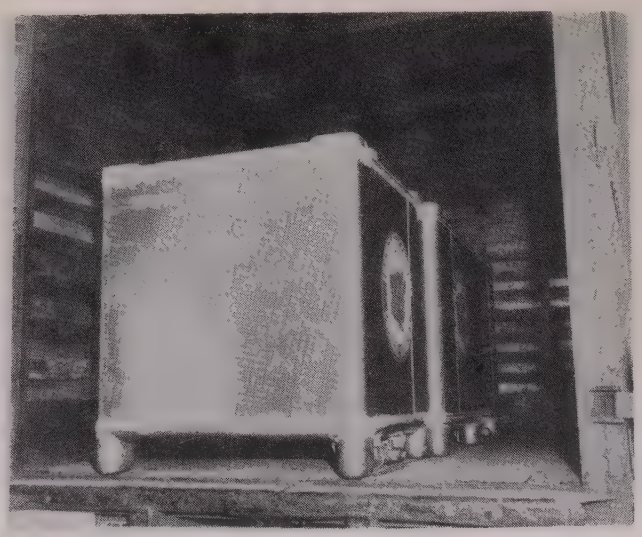
Advantages of Borden Tote Bins Are:

1. Reduces handling cost in plant—only one container is loaded, unloaded and moved about—versus five containers when packed in drums.
2. Less waste—adhesives in drums cannot be completely drained, resulting in several pounds loss per container. With tote bins, only one container is involved versus five, so adhesive hangup loss is decreased by tote bins.
3. Simplifies inventory.
4. Available at no increase in price to customer—same price as drums
5. No capital investment by customer required.
6. Cuts down storage space.

Liquid Resins

The use of tote tanks for liquid resin shipping is intended to reduce material handling and provide for a more flexible supply of resin in our customer mills. A tote tank holds more resin and occupies less space than five 55-gallon drums. A full supply of resin can be stored at the point of use in a container that can be drawn from by simply opening a valve. Tote

Removing from storage in Springfield plant by fork-lift



Three tote tanks on small trailer

Discharging is easier with tote tank than with drums

tanks are constructed of light but strong aluminum, that is resistant to all but highly alkaline resins.

A Borden salesman now must sell a method as well as a product, but the advantages make this not at all difficult for the lively, creative sales force of Borden. The salesmen have been ingenious in adapting this to plants where there is no fork lift nor use for one, by making carts so the bins could be wheeled around. The carts also serve, in some plants, as discharge platforms.

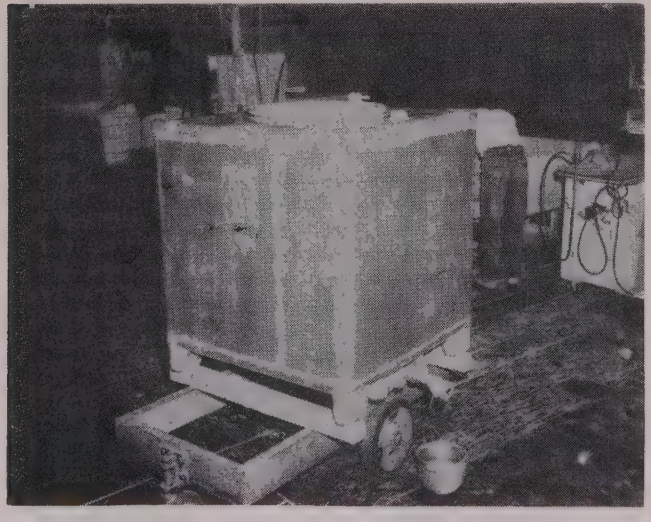
The following Borden memos show the creativity of one Borden salesman, who was faced with such a problem:

"I am enclosing four snapshots of the tote tank trailer which was designed and built by Pilot Rock Lumber Co.

"The wheels are old pulley wheels they had out in the junk pile. They bored out the wheels and inserted used Timken roller bearings. The front wheel assembly rotates on a Timken roller bearing (about 8-in. diameter, 1-in. thick with the points down). The bearing was one that was no longer suitable for the high speed production machines, so that you can see they did not go to much expense.

"They generally pull the loaded trailer by hand (that is two men) although the trailer is stable enough to be towed by a lift truck . . ."

Borden is quite pleased with the operational efficiency of the tote tanks in the west and northwest where the containers serve as an adjunct to trucks and drums. Overcoming minor customer resistance early, acceptance now has been so great that at present, bins can be supplied only to companies using a bin a month, a high quantity since the products normally are used in small batches.



Special truck made from junk serves as discharge platform at lumber plant

In shipping by common carrier truck, Borden includes a return bill of lading. Material is shipped to customer and back to Borden, f.o.b. plant, freight allowed.

Besides the Springfield and Los Angeles plants, tote tanks are warehoused at and shipped from Kent, Wash., where Borden has a formaldehyde plant.

Besides the liquid adhesives and resins tote is handling for Borden and its customers, the Beatrice, Neb., firm also handles liquid sugar, liquid chocolate, polyvinyl alcohol, and lacquers.

The dry tote bin, now in use for over a decade, is handling materials used across the industrial horizon.

New Food Toxicity Dilemma may be Resolved by Atom Research

Public Law No. 929 of the 85th Congress amended the Federal Food, Drug, and Cosmetic Act of 1938. The bill became law on Sept. 6, 1958, after being signed by President Eisenhower, and made several important changes in the regulations governing the use of food additives.

The original (1938) law permitted the addition of chemical additives to food without pretesting to establish their safety. If ill effects were suspected, the Food and Drug Administration was required to make the laboratory investigations. These tests may have required 2 or more years to perform, and during this period the food containing the suspected additives continued to be sold. The new law requires pretesting of new food additives by the manufacturer or processor.

The new law recognizes the fact that substances which have harmful effects above certain concentrations may be perfectly safe at much lower levels and permits the use of most* substances at safe levels if their use will advance or improve food technology (i.e., by retarding spoilage). The previous law barred the use of any substance known to be poisonous or deleterious even if there was an established "safe level" at which it was not harmful.

Any food additive which is *not* generally recognized by qualified experts as safe under the intended conditions of use is subject to this act. Old as well as new chemical food additives are covered if their use is not known to be safe. However, for food additives in commercial use prior to Jan. 1, 1958, the law allows 18 months for the development of the necessary safety date, provided there is no evidence that the material may be unsafe.

Although this law applies specifically to food additives, it emphasizes the concern generally prevalent among health experts over the possible effects of minute traces of untested chemical compounds in the diet. As the science of food technology becomes increasingly more complex, the problem of insuring the freedom of foods from possibly harmful materials becomes correspondingly complicated. Consider for a moment the possible methods by which foreign chemicals, safe as well as harmful, can find their way to the consumer's table. Vegetable food products may contain pesticide residues. In the processing plant the food may extract chemicals from the handling equipment (i.e., conveyor belts, rubber or plastic tubing). In addition to substances which unintentionally find their way into the food, there are numerous chemicals which are intentionally added to accomplish a specific purpose. Among these are processing aids such as defoamers, anticoagulants and emulsifiers; preservatives to retard spoilage; seasonings to improve flavor; additives to modify flavors; and dyes or pigments to make coloring more uniform and attractive. Following preparation, the food must be packaged for delivery to the consumer. The packaging material may be a source of further contamination,

* No substance known to have caused cancer in animals or men may be used, at *any* concentration.

as well as the inks, dyes coatings, and adhesives used on it.

The basic procedures for evaluating the safety of various materials are outlined in "Principles and Procedures for Evaluating the Safety of Intentional Additives in Foods" (prepared by the National Research Council), and in publications by the Food and Drug Administration. A review of the methods used and the data required reveals countless ways in which the use of radioisotopes and tracer techniques can save both time and money to food research workers.

Tracer techniques offer three important advantages to food researchers. They are: (1) extremely high sensitivity, (2) quick results, and (3) relative ease of use. To a manufacturer anxious to determine the feasibility of a new product, all three are important in terms of money and time.

Pesticides. Since most pesticides are acknowledged to be toxic, the important consideration is whether or not they appear in the final prepared product. A small portion of pesticide synthesized from radiochemicals can be used to treat a control crop. Then following the normal growth cycle, the crop is harvested and processed in the usual manner. A radioassay of the finished product will then show if the pesticide does appear and, if so, in what concentration.

Food Additives. Much important information concerning the use of a food additive can be gained from tracer techniques. Uniformity of dispersion, precise concentrations, and the mechanism by which they perform their functions are but three. When conducting *in vivo* animal tests on the physiological effects of an additive, tracer techniques can easily ascertain the amount of the additive metabolized and the amount passing through the animal body without being absorbed. Within the body, concentrations of the additive in specific areas or organs are readily located.

Food Packaging. The migration or absorption by food of substances in the packaging material is of particular interest. Many of the newest packaging materials are plastics and contain plasticizers, stabilizers, antioxidants, and other compounding ingredients whose presence in food would be considered undesirable for esthetic as well as for health considerations. Other packaging contains printing inks, adhesives or coatings whose presence in food is also undesirable. Studies have shown that suitability of a given packaging material varies with the foods packaged. For example, a plastic that is suitable for use with vegetables or fruits might not be permitted to be used in contact with meats and butter because these fatty compounds would extract the plasticizer. Today's philosophy in the use of food packaging materials is not to prove that a given substance is nontoxic (this could require months or years of animal tests), but rather to prove that this material is not absorbed by the food with which it is in contact. Tracer techniques, which are capable of determining concentrations in the 0.01 p.p.m. range, are the quickest and most economical method of obtaining the required proof.

Tracerlab has had considerable experience in work of this type and, in fact, conducted a three-day symposium on "The Applications of Radioactivity in the Food and Food Processing Industries" several years ago. Radiochemical equipment and methods are readily applied in most laboratories and, when all factors are considered, are economically justified with very little difficulty. Members of Tracerlab's Radiochemical Department have worked with food processors and food packagers on all phases of problems similar to those outlined above, from supplying them with specially synthesized radiochemicals to conducting experiments designed to obtain data for presentation to the Food and Drug Administration. Just recently; Tracerlab completed work on two such problems; a study of the migration of antioxidants from a plastic packaging material into a dairy product, and a study of the milk solubility of several types of adhesives used in cardboard milk containers.

U. S. Chemical Trademarks

Registered U. S. Chemical Trademarks have now been completely cataloged in the files of the Cheminform Institute, Coliseum Towers, New York City 19.

In addition there are listed unregistered trademarks, common, generic, and trivial names and synonyms of chemicals, drugs, cosmetics, food additives, coatings, fibers, alloys, insecticides, fungicides, plastics, plasticizers, emulsifiers, lubricants, pigments, dyes, waxes, surfactants, detergents, resins, and chemical compositions for use in all industries. The chemical composition, use, and manufacturers are given. Foreign products are included.

A leaflet describing this information service is available.

Sulfite Liquor By-Products

Research funds for stream improvement and utilization of sulfite pulping by-products got the green light when major pulp and paper companies approved next year's budget of Sulfite Pulp Manufacturers' Research League at a level 6.4% above 1959 expenditures. Trustees of the Research League held their annual meeting at League headquarters on the campus of The Institute of Paper Chemistry and approved an outlay of $163,500 for research and development in the year ahead.

Officers elected for 1960 are: *President,* Stanton W. Mead; *vice-president,* W. R. Haselton, vice-president, Rhinelander Paper Co. Division of St. Regis Paper Co., Rhinelander; *treasurer,* P. M. Chiuminatto, vice-president of Charmin Paper Products Co., Green Bay; *secretary,* John G. Strange, president of The Institute of Paper Chemistry, Appleton.

FDA Approves Patapar Vegetable Parchment

Patapar vegetable parchment has been accepted by the Food and Drug Administration as meeting the requirements of the 1958 Food Additives Amendment to the Federal Food, Drug and Cosmetic Act. Patapar is a product of the Paterson Parchment Paper Co., Bristol, Pa.

Missile Cushions

The rubber-coated fabric air bag fastened to the Mace missile shown is one of two inflatable "cushions" used as landing gear by the Air Force to recover the vehicle.

Two recovery bags fit snugly around the belly of the vehicle when popped into shape by compressed air during a landing. Manufactured exclusively by the Aviation Products Division of the Goodyear Tire & Rubber Co., they cushion the Mace during landing and are a vital part of the recovery system used in returning the missile to the ground without damage.

Missile cushions

Wastepaper Symposium

The Wastepaper Utilization Council is holding a two-day national symposium on June 7 and 8, 1960, at the Conrad Hilton Hotel in Chicago.

Details of the program and registration procedure will be available at a later date.

Corrosion Test Samples

To facilitate laboratory testing of various materials of construction in corrosive environments, The Pfaudler Co. has developed a variety of test samples which are available to equipment users. The types of samples, materials of construction, and recommended testing procedures are explained in Pfaudler Bulletin 981. The new bulletin replaces Bulletin 919 which covered the same subject but listed considerably fewer available test metals.

Samples available include Glasteel disks, test cups and dumbbells, as well as tabs of tantalum, titanium, zirconium, Hastelloy alloys, stainless steel and other metals and alloys.

Appropriate equations for determining corrosion rate in mils penetration per year (MPY) are included for both metal and alloy, and Glasteel samples.

Further information may be obtained by requesting Bulletin 981 from The Pfaudler Co., 1106 West Ave., Rochester, N. Y.

U. S. Forest Products Laboratory

Reports Available

Three technical reports on foreign woods are available. "Mahogany," Report No. 2167, describes the physical and mechanical properties of true Central and South American mahogany along with some other characteristics of this long-popular wood. "Determining Preservative Retention in Piling by the Assay of Borings," Report No. 2172, describes a method of checking the amount of preservative retained in various kinds of wood piling to evaluate the quality of treatment. "Groundwood Pulping of White Fir and Corkbark Fir," Report No. 2175, gives results of groundwood pulping experiments along with a summary of the use of these pulps in papermaking.

Single copies of these reports are available free upon request to the Director, Forest Products Laboratory, Madison 5, Wis.

Glossary of Packaging Terms

Planning has begun for revision and updating of the Packaging Institute's "Glossary of Packaging Terms" and publication of the third edition of this basic reference for the packaging industry. The enlarged edition will contain more than 125 new definitions submitted by the U. S. Government services plus a large number which have been collected since publication of the second edition in 1955, and many more are expected to be accumulated by the Glossary Revision Committee.

Directory of University Research Bureaus & Institutes

The Directory is a reference guide to university research bureaus, institutes, centers, experiment stations, laboratories, etc., set up on a permanent basis and carrying on a continuing program of research in specialized fields.

The book contains 1500 listings in 250 fields including: business, population, education, engineering, public administration, electronics, Slavic studies, tropical meteorology, cosmic rays, personality assessment, insect pathology, folklore, Russian studies, explosives, labor relations, community planning, aeromedical and physical environment, judicial administration, etc.

The Yale Research Co. has scheduled the publication for March 15.

OBITUARIES

Truls Biornstad

Truls Biornstad, general director, The Kellner-Partington Paper Pulp Co., Ltd., Hallein bei Salsburg, Austria, died in October, 1959.

Mr. Biornstad was 59 years old. From 1923 to 1927 he was with the National Bank of Chicago. He joined the Kellner-Partington Paper Pulp Co. in 1927 and has been a TAPPI member since 1953.

Curt Weil

Curt Weil, a pulp and paper mill engineer for Ebasco Services, Inc., died Dec. 23, 1959.

Mr. Weil was born Sept. 5, 1897, in Dusseldorf, Germany, and went to the Technische Hochschule Darmstadt, graduating in general engineering in 1923. He came to the United States in 1929 and was a design engineer for Paper & Industrial Applicances, The Chesapeake Corp., Warren Steam Pumps Co., The Dorr Co., H. A. Brassert Steel Mills and Roderick O'Donoghue before going with Ebasco. He became a member of the Association in 1934.

Francis I. Kittredge

Francis I. Kittredge died Oct. 24, 1959. A graduate of Worcester Tech in 1922, he joined the General Electric Co. immediately after graduation and was Manager of Industrial User Sales in the Philadelphia office at the time of his death. He was 60 last November.

Mr. Kittredge became a member of TAPPI in 1948.

John Keith Russell

John Keith Russell, Assistant General Manager of Lignosol Chemicals Ltd., Quebec, died Jan. 28, 1960, in his 54th year.

A native of Lower Newcastle, N. B., Dr. Russell graduated from Dalhousie University, Halifax, and obtained a Ph.D. in physical chemistry from McGill University, 1934. He made many significant contributions to the study of cellulose and the developments of useful products from spent sulfite liquor. He was awarded the Weldon Medal in 1950 by the Technical Section, Canadian Pulp and Paper Association, and was made a Fellow of the Chemical Institute, 1956.

After graduation from McGill University, he was Research Chemist for Canadian International Paper Co., Port Hawksbury, 1934–41. He then was Superintendent of Welland Chemical Works, 1941–42, later becoming Director of Research, Allied War Supplies Corp., 1942–44. In 1944, he became Chief Research Chemist for Northeastern Paper Products where his researches on the utilization of sulfite liquor led to the commercial production of the Lignosol products. During his nine years with Lignosol Chemicals Ltd., he saw the company grow from pilot plant production to a major producer of lignosulfonates used as a tanning aid in the leather industry, as a binder for firebrick, and as a dispersant for Portland cement, boiler water treatment, clays, and oil drilling fluids. He holds several basic patents for the commercial preparation of lignosulfonates.

He was a member of the following societies: American Chemical Society; Society of Chemical Industry; The Chemical Institute of Canada; Technical Section, Canadian Pulp & Paper Association and TAPPI (1947).

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Civil Engineering Committee Meeting

The Civil Engineering Committee met in the Grant Room, Hotel Sheraton, Pittsburgh, Pa., 12:30 to 1:25 p.m., Oct. 12,1959. Present were William Pittam, John H. Bringhurst, Jr., Gerald E. Smith, Robert A. Jackson, John H. Beaver, Jr., Lawrence L. Wallace, C. Elliott Bouis and H. O. Teeple. Absent were Carroll Allen, Bernard M. Center, F. J. Maslyk, and Kurt H. Siecke.

The luncheon meeting was called to order by the chairman, Mr. Pittam. Mr. Pittam introduced H. O. Teeple of TAPPI Headquarters and Lawrence L. Wallace of John G. Hoad and Associates, Inc., who is a new committee member.

Mr. Pittam announced that John Bringhurst, Jr., has resigned as vice-chairman because of health. The vice-chairman's office will remain vacant until a qualified mill man is found to fill this vacancy. Mr. Pittam will retain the chairmanship for the next year as well as C. Elliott Bouis, who will continue on as committee secretary.

It was decided that the Civil Engineering Committee would have an interim luncheon meeting at the annual New York meeting in February.

The committee requested Mr. Teeple to contact ASCE Headquarters in New York to see if they had a listing of their members in such a manner that we could contact members who work for pulp and paper mills. He is also to advise the committee on the possibility of an interim committee meeting during an ASCE convention.

Mr. Pittam requested that all members submit a list of proposed projects, prospective papers and suggested data sheets. He would like this material in 6 weeks.

Mr. Pittam then reported to the committee on the report which he gave to the Engineering Division Staff Advisory Committee meeting on Sunday afternoon.

The discussion again came up as to whether the name of the committee should be changed or whether it should be kept as Civil Engineering. The Committee again come to no conclusion and as a result the matter was again tabled.

The meeting was adjourned at 1:25 p.m.

C. Elliott Bouis, *Secretary*

Civil Engineering Committee

C. Allen, Southern Pine Lumber Co., Diboll, Tex.
J. H. Beaver, Hoffman Construction Co., Portland, Ore.
C. Bouis, Secretary, Southwestern Engineering Co., Los Angeles, Calif.
J. H. Bringhurst, J. E. Sirrine Co., Greenville, S. C.
B. M. Center, Center-Maltz & Associates, Brooklyn, N. Y.
R. A. Jackson, Chicago Bridge & Iron Co., Seattle, Wash.
F. J. Maslyk, Stone & Webster Engineering Corp., New York, N. Y.
William Pittam, Chairman, Stone & Webster Engineering Corp., P. O. Box 38, Toledo, Ore.
K. H. Siecke, Siecke-Kurtichanof-Dorner, Portland, Ore.
G. E. Smith, The Rust Engineering Co., Pittsburgh, Pa.
L. L. Wallace, John G. Hoad and Associates, Inc., Ypsilanti, Mich.

Civil Engineering Committee

Drying Committee

A meeting of the Drying Committee was held Dec. 8, 1959, 11 a.m., at the Airport Hotel, Pittsburgh, Pa.

Members in attendence were:

S. G. Holt, G. E. Jackson, K. Khandelwal, L. Blomgren, A. J. Cirrito, W. A. Green, Jr., L. G. Janett, G. Kerikorian, R. C. Swaney, L. R. Vianey, S. G. Williams, H. O. Teeple

Guests:

R. H. Murray and W. Antonachio of American Gas Association

Members absent:

G. H. Cash, F. L. Cessna, Jr., R. M. Cook, E. G. Drew, H. P. Fishwick, A. Hallencreutz, S. T. Han, J. J. Kilian, G. R. Lydick, J. M. Mallory, W. F. Overly, R. A. Paramore, F. G. Perry, N. M. Reitzel, R. C. Portouw, H. W. Stevens, R. E. White

The meeting was called to order at 11:00 a.m. by S. G. Holt, chairman. The minutes of the previous meeting were approved.

Mr. Murray and Mr. Antonachio of American Gas Association were introduced to the committee.

Mr. Murray gave a short report on "The Heating and Drying Symposium" sponsored by the American Gas Association (A.G.A.) and the Ohio Section of TAPPI on Sept. 15, 1959, in Middletown, Ohio. This program was reported to be a success and all the papers were published in November, 1959, issue of *Tappi*. The A.G.A. would like to arrange similar programs for other sections of TAPPI and possibly for the TAPPI Engineering Division's National Meeting.

A.G.A. would like to know the type of papers that would be of most interest.

It was decided that the Drying Committee will plan on two, half-day, sessions at the Jacksonville meetings Oct. 24–28, 1960. One half-day session will be devoted to an "Infrared Drying Symposium" which will include a paper on the Smithern process by H. L. Smith, Jr., and several other speakers arranged for by R. H. Murray of American Gas Association. It was agreed that Mr. Murray will make up a proposed program for the remaining portion of the session on infrared drying and submit it to H. O. Teeple for transmittal to the Drying Committee members. This program will be among the items discussed during the committee luncheon to be held during February TAPPI week in New York City.

The other session will be devoted to a symposium on high velocity air drying which will consist of one or more papers on the fundamentals of high velocity air drying and a panel of mill men with some experience in using high velocity driers. This topic is discussed further under Project 760 below.

Status of Active Committee Projects

Project No. 505—Drying Rates of High Pressure Driers.

L. G. Janett reported that the interim report was presented at the Pittsburgh meeting of Engineering Division. More correlation work on the data remains to be done. The target is to get the Yankee correlation final report by February, 1960. Mr. Janett estimated that if someone from outside was employed to do the correlation it may take 80 to 100 hr. of time. H. O. Teeple is to look for funds and farm out the correlation work to students at one of the colleges. Mr. Holt is to write a proposal for appropriation of funds from TAPPI. The subcommittee handling this project will hold a meeting in the near future according to Janett.

H. O. Teeple stated that many questionnaires were returned with no data because these mills were not using high pressure driers. 15 to 40 p.s.i. is the high range of low pressure driers and possibly we could use the data. Mr. Teeple is to supply a list of companies that returned above questionnaires to Mr. Janett so that we can approach them for data at a later date.

Project No. 750—Pressing. A paper on wet pressing presented by Dr. White in Pittsburgh October, 1959, meeting was the objective of this project. This project is closed.

Project No. 755—Data Sheets. S. G. Holt to write to H. W. Stevens for a report. G. E. Jackson is responsible for the activities of this group. A data sheet on Power Loss in Air Ducts was suggested if sufficient information is not available in the usual handbooks.

Project No. 756—High Frequency Drying. L. R. Vianey had no progress to report and it was decided this project be dropped as there is little interest in this as compared to infrared heating.

Project No. 757—Radiant Heating. A new subcommittee created to take charge of this project as follows: R. C. Swaney—chairman, J. J. Killian, L. Blomgren, W. A. Green.

R. C. Swaney is to write up a new objective for this project and change to "All Radiant Heating" from "Gas Radiant Heating." This subcommittee is to be responsible for the one half-day symposium on infrared heating at Jacksonville meeting.

Project No. 759. This project is related to the use of gas turbines in the pulp and paper industry. No further effort devoted but the project is to be held open.

Project 760—Air Jet Driers. S. G. Holt is to invite C. Allander of the Swedish Flakt Co. to present a paper on the fundamentals of high velocity air driers. Lars Blomgren will do the follow-up work on this invitation. This talk will represent one portion of the half-day symposium on higher velocity air drying to be held at Jacksonville. There is a possibility a second speaker can be contained to cover any other aspects which Dr. Allander may not wish to discuss in his paper. Most American suppliers of high velocity air driers were contacted and asked to participate in this symposium. It was the committee's opinion that interest in this subject was high and that a greater service would be rendered by presenting the papers as soon as possible. Equipment manufacturers will be contacted and asked to participate.

It was suggested the committee should consider dividing the symposium into two parts. First, a discussion of fundamentals and, second, a panel of mill men who have been using various types of commercial equipment. It was further suggested that the suppliers of equipment be asked to suggest a mill representative who might be in a position to serve on this panel.

Under this same project the committee is also attempting to find methods for expressing the water removal abilities or coefficient of performance of high velocity air hoods for driers.

It was pointed out that certain similarities exist between the heat transfer and mass transfer properties of air hoods. This could lead to some standardized testing procedures.

A second suggestion was made to the effect that the present test methods for cylindrical driers be extended to high velocity air drying hoods including such factors as fan horsepower and thermal energy used.

A new project is to be set up to develop good methods for moisture sampling. This project could conceivably lead to a paper and possibly a data sheet.

The following members were named to the subcommittee. Pohlman—chairman, Kerikorian, Reitzel. S. G. Holt is to write to Messrs. Reitzel and Pohlman.

S. G. Holt is to write a report to Staff Advisory Committee.

A committee meeting will be planned for late May, 1960, in Wisconsin. The next committee meeting will be a luncheon meeting at TAPPI National Meeting in New York in February, 1960.

The meeting was adjourned at 4 p.m.

K. K. KHANDELWAL, *Secretary*

Engineering Economics Committee

The Economics Committee held a luncheon meeting in the club room of the Penn-Sheraton Hotel, Pittsburgh, Pa., on Oct. 12, 1959.

Members present: F. C. Holmes, J. E. Kearney, R. C. Polk, A. S. Robertson.
Guests: W. B. Wilson of General Electric, W. H. Brickner of Mead Corp., J. D. Lyall of Armstrong Cork.

F. C. Holmes, secretary, presided in the absence of G. W. Sargent, chairman. The two papers to be presented Tuesday were discussed. Everything all set. Mr. Brickner had 100 copies of his paper and Mr. Reul had 125 copies of his paper for distribution at the session.

SUBCOMMITTEE REPORTS

A. Ray Marsh not present, so no report on "Bibliography of Articles on Economic Justification."

B. Howard Baumgarten not present, so no report on "Methods and Guides for Developing Estimates and Justification of Projects."

PAPERS FOR 1960

A. Mr. Packard not present to present rough draft of possible paper on "Economics of Preventive Maintenance." Will discuss at luncheon meeting in New York City in February.

B. Joe Voci not present to present rough draft of possible paper on "Economics in Estimating." Will discuss at luncheon meeting in New York City in February.

Possible new papers and sources of suitable authors were discussed. Follow-ups were assigned to various committee members.

A. "Batch Pulping versus Continuous Pulping."
B. "Minton Drier versus Conventional Drier."
C. "Economics of Basis Weight Control." A. S. Robertson

Engineering Economics Committee, G. W. Sargent, Jr., chairman

said he would try to get some information available for meeting in February.

D. "Economics of High Velocity Drying."

E. "Economics of Off versus On Machine Coating." Will discuss further in New York City.

F. Possible paper on "Economic Trends."

G. "Economics of Inverform versus Cylinder Machine on Board Grades." Will discuss further in New York City.

H. "Long Range Economics of Paper Machine of the Future." Will discuss further in New York City.

I. "Economics of NSSC versus Straw and Waste on Corrugating Medium."

A current roster of Committee members follows.

F. C. Holmes, *Secretary*

G. W. Sargent, Jr., *chairman*, Mercury Engineering Corp., Milwaukee, Wis.
F. C. Holmes, *secretary*, Bird Machine Co., Evanston, Ill.
R. C. Polk, Appleton Machine Co., Appleton, Wis.
P. J. Toma, Time, Inc., Springdale, Conn.
G. D. Lewis, Dominion Engineering Co., Ltd., Montreal, Que., Canada
R. Marsh, Walter Kidde, Engineers, Houston, Tex.
R. A. Packard, Hopkinton, Mass.
A. S. Robertson, Albemarle Paper Manufacturing Co., Richmond, Va.
J. J. Voci, Arthur D. Little, Inc., Saugus, Mass.
William Pittam, Stone & Webster Engineering Corp., Toledo, Ore.
J. E. Kearney, Ebasco Services, New York, N. Y.
C. Allen, Fibre Products Div., Southern Pine Lumber Co., Diboll, Tex.

Mechanical Engineering Committee

An interim meeting of the Mechanical Engineering Committee was held at 10:00 a.m., Jan. 12, 1960, in the conference room at TAPPI Headquarters, New York, N. Y. The following were present.

J. S. Mudgett, *vice-chairman*, Strathmore Paper Co.
J. C. Harper, *secretary*, Rice Barton Corp.
H. O. Teeple, TAPPI
R. T. DePan, H. K. Ferguson Co.
P. A. Fasoli, C. H. Dexter & Sons
C. E. Hill, West Virginia Pulp & Paper Co.
L. A. Moore, Black Clawson Co.
F. A. Taska, Clark & Vicario Co.

The meeting was called to order by J. S. Mudgett who made a few appropriate remarks concerning the passing of former chairman "Deac" Davis.

Reading of the minutes of the preceding meeting was omitted as copies had already been mailed to all members.

J. S. Mudgett brought up the question of the best procedure to be followed in connection with the letters that were written to those who expressed interest in the committee at the last Engineering Conference. Approximately 24 letters were written with replies received from about 50%. Of those replying, eight have signed or indicate intention to sign applications.

At the Steering Committee meeting in December, G. H. Spencer took note of several names of men that he planned to call on personally and he will submit a report at the February meeting. J. S. Mudgett plans to write follow-up letters to all of those who have not replied.

F. A. Taska advised that H. V. Miles of Dorr Oliver Co., Stamford, Conn., is interested in the Subcommittee on Vacuum Pumps and will be invited to send in an application for membership.

Following a general discussion of methods to be used to encourage new members to join activity in the work of the committee, the secretary was instructed to prepare and send to all members a list of the names and addresses of all members of the committee. Also to be included with this mailing there is to be a copy of the statement of the aims and objects of the Mechanical Engineering Committee as it appears in the Engineering Division manual. It is hoped that this type of publicity may help to arouse interest in and bring new members to the group.

It was further suggested that there are several subcommittee members who may now be interested in establishing full membership and they are to be sent application blanks with these minutes.

Subcommittee Reports

Wood Preparation: Chairmanship vacant.

As previously reported, there is the problem of staffing and membership. J. S. Mudgett plans to address letters to key people in mills that have basic wood preparation installation requesting their cooperation and suggestion of names of qualified engineering personnel who would be interested in committee work. The members present felt this increasingly important segment of the paper industry should receive more attention and publicity from the Mechanical Engineering Committee. Included with the letters will be an invitation to attend the committee meeting in February to become acquainted with other committee members.

Pulp Preparation. R. T. DePan, chairman, F. C. Duvall, secretary.

Tentative plans are being formulated for a program presentation at the 16th Engineering Conference in 1961, this to consist of a series of papers on the mechanical design and operational features of continuous digesters. Preprints of papers are to be made available at the meeting, with each being presented by summary, followed by general discussion.

The design of equipment for the continuous refining of rag stock was proposed as a possible subject, providing it was felt to be of sufficient interest.

A third possible subject for a paper or papers would be the advantages, disadvantages, and reasons for the various basic designs of refiners.

Paper Machine. C. E. Hill, chairman, F. A. Taska, secretary.

The papers for the program at Jacksonville were approved in accordance with the list recommended by the Steering Committee in December as follows.

1. "Uniform Nip Loading Control of Machine Calenders." Data from Black Clawson Co. with author's name to be advised later.
2. "Calender Nip Pressure Distribution as a Function of Local Roll Crowns and Temperature Variations," Kimberly-Clark Corp. Author's name to be advised.
3. "Mechanical Design and Installation Requirements of Trailing Blade Coater Equipment." J. P. Munton, chief engineer, Rice Barton Corp.

After considerable general discussion it was agreed there probably would be sufficient time in the schedule to include a fourth paper. Since the planned papers deal primarily with paper machine operation, it was suggested that the Pulp Preparation Subcommittee be given the opportunity to produce a suitable paper. R. T. DePan was confident that he could procure a suitable article on the subject of refiners and will report on this at the February meeting.

The subcommittee group which has been working on material for data sheets on vacuum pumps is about ready to present material for approval as follows.

1. Vacuum Pump Requirements of the Paper Machine.
2. Methods for Taking Measurements of Paper Machine Vacuum.
3. Air Entrainment in Barometric Discharge (Revision of existing Data Sheet No. 10.)

A fourth data sheet on Rotary Suction Box Vacuum Requirements will be forthcoming in the near future.

Returning to the Paper Machine Subcommittee, the following subjects were suggested for future papers.

1. Optical (Axicon) method of machine and roll alignment.
2. Problems of machine levels and installation tolerances. This is to be a joint effort of mill engineers, consulting engineers, and instrumentation engineers.

3. Supercalendering on the paper machine.
4. Report on the problems of design for future machine speeds of 4000 f.p.m. and 360 in. width.
5. Metallurgy of suction roll shells.
6. Methods of measurement of vacuums in suction rolls, with an explanation of the basis of the new data sheet.
7. A study of the problem of "barring" previously mentioned at the steering committee meeting.

Finishing & Converting: R. W. Brown, chairman.

No report received from this subcommittee. J. S. Mudgett plans to check into this situation and determine whether anything can be done to stimulate activity.

Meeting adjourned at 4:00 p.m.

J. C. HARPER, *Secretary*

MECHANICAL ENGINEERING COMMITTEE MEMBERSHIP

R. W. Brown, Fitchburg Paper Co., Fitchburg, Mass.
J. W. Crocker, Stone & Webster Eng. Corp., 850 Eperson Bldg., Houston 2, Tex.
R. T. DePan, H. K. Ferguson Co., Ferguson Bldg., Cleveland, Ohio
F. C. Duvall, Black Clawson Co., Pandia Div., Hamilton, Ohio
P. A. Fasoli, C. H. Dexter & Sons, Windsor Locks, Conn.
R. P. Finney, St. Regis Paper Co., East Pepperell, Mass.
W. F. Fields, Armstrong Cork Co., Lancaster, Pa.
P. H. Goldsmith, Dominion Eng. Works, Ltd., Montreal, Que.
J. C. Harper, Rice Barton Corp., Worcester, Mass.
C. E. Hill, West Virginia Pulp & Paper Co., Covington, Va.
B. M. Hutchins, Rust Engineering Co., 575 Fifth Ave., Pittsburgh, Pa.
H. G. Ingraham, Charles T. Main, Inc., 80 Federal St., Boston, Mass.
D. E. Jones, E. D. Jones & Sons Co., Pittsfield, Mass.
R. A. Jordan, Great Northern Paper Co., Millinocket, Me.
E. J. Justus, Beloit Iron Works, Beloit, Wis.
B. L. Merriss, Oxford Paper Co., West Carrollton, Ohio
L. A. Moore, Black Clawson Co., Watertown, N. Y.
J. S. Mudgett, Strathmore Paper Co., West Springfield, Mass.
G. H. Spencer, The Torrington Co., South Bend, Ind.
J. O. Starkweather, Ebasco Services, Inc., 2 Rector St., New York 6, N. Y.
F. A. Taska, Clark & Vicario Corp., North Tarrytown, N. Y.

The following names are those who have recently expressed interest in the committee work, are former members who have not renewed their memberships, or are presently serving on a subcommittee.

D. L. Calkins, St. Regis Paper Co., Jacksonville, Fla.
P. B. Hare, Buckeye Cellulose Co., Foley, Fla.
Watson Brown, Champion Paper & Fibre Co., Pasadena, Tex.
G. W. Reynolds, Rome Kraft Co., Rome, Ga.
D. L. Shinn, Crown Zellerbach Corp., Camas, Wash.
E. S. Skinner, Beloit Iron Works, Beloit, Wis.
H. V. Miles, Dorr Oliver Co.,.Stamford, Conn.

The Mechanical Engineering Committee of the Engineering Division of TAPPI has as its objectives:

1. To seek out and define problems of a mechanical or structural engineering nature whose solutions would benefit reasonably wide segments of the pulp and paper industry.

2. To encourage attach on these problems by discussion, publication, and by sponsorship of research.

3. To bring to the attention of the industry, through meetings and publications, new and potentially useful engineering techniques or new applications of old techniques.

Sanitary Engineering Committee

The Sanitary Engineering Committee Meeting, Penn Sheraton Hotel, Pittsburgh, Pa., was called to order at 1:35 p.m., Oct. 12, 1959, by the chairman, immediately following the luncheon. The following people were present.

W. A. Moggio, *chairman*, St. Regis Paper Co.
L. L. Klinger, *secretary*, Whippany Paper Board Co.
M. J. Osborne, Eng. Division, Bowaters Southern Corp.
H. T. Robson, for G. C. Kimble, Union Bag-Camp Paper Corp.
R. W. Simpson, Gilbert Associates, Inc.
C. V. Spangler, guest, J. F. Pritchard & Co.
Vernon Stack, for Roy F. Weston, Roy F. Weston, Inc.

Sanitary Engineering Committee, W. A. Moggio, chairman

Mr. Moggio briefly reviewed the preceding Sanitary Engineering Committee meeting held in New York at the Commodore Hotel, Feb. 24, 1959. At that time the question was raised as to possible conflict of interest and duplication of effort on the part of the Sanitary Engineering Committee with other TAPPI Committees and pulp and paper industry organizations with similar interests. After some discussion it was decided, to everyone's satisfaction, that although similarity of interests existed, no conflict or duplication of effort existed provided the Sanitary Engineering Committee's activities were directed toward the engineering aspects of water and effluent handling. Accordingly, the outline of the committee objective and scope of activities was approved by the committee membership.

Also at the February, 1959, meeting the committee selected the theme for the Sanitary Engineering Session for the 14th Engineering Conference. The theme selected was "Air—Its Role in Waste Treatment and Disposal."

A brief review of the papers to be presented at the Sanitary Engineering Session of the Engineering Conference was made. The following papers were presented, in keeping with the previously selected theme:

"A Rational Approach to Aeration Methods Involved in Backwater Solids Recovery," by L. L. Klinger.
"Oxidation Lagoons," by R. O. Blosser.
"Turbine Aeration and Other Methods for Reaerating Streams," by A. J. Wiley and B. F. Lueck.

Mr. Simpson presented a brief report on Data Sheets activities which were pertinent to the committee. After some discussion as to types of Data Sheets which would be of use to the industry, the members decided to initiate activity on the following.

1. Compilation of nonclassical or unique flow measurement methods for measuring waste flows. Since many of the classical or standard flow measurement methods are not applicable in pulp and paper mills, because of physical or financial limitations, a compilation of some of the more ingenious, nonclassical methods would be useful to industry personnel faced with the task of obtaining reasonably accurate waste or water flow measurements.

2. Glossary and definition of terms used in water supply and waste treatment for the purpose of standardizing the interpretation of sanitary engineering data in the industry.

Discussion of other areas in which the Sanitary Engineering Committee could be of service resulted in the suggestion that the B.O.D. and/or C.O.D. of various papermaking additives be determined as a guide to their usage with respect to the lowering of B.O.D. values of pulp and paper mill effluents. This undertaking could serve as the basis for a research project.

The preparation of an annual review of the literature covering pulp and paper mill effluent disposal and treatment and stream pollution for possible publication in *Tappi* was also discussed. Such a review could serve as a handy reference for industry personnel concerned with these prob-

lems and aid them in keeping up with current developments.

The committee membership decided that no papers be sponsored for the forthcoming Annual Meeting of TAPPI in New York.

The theme of "Water Resources" was selected to serve as the basis for a Sanitary Engineering Committee session for the 15th Annual TAPPI Engineering Conference in Jacksonville, Fla.

The meeting was adjourned at 2:20 p.m.

L. L. KLINGER, *Secretary*

SCOPE OF ACTIVITIES AND OBJECTIVES

Collection, study and dissemination of engineering information and methods as they apply to the pulp and paper industry in the areas of water supplies, liquid effluents, atmospheric discharges, solid residues, receiving waters, and survey techniques.

1. Water Supplies
   - A. Ground and Surface Supplies
     - (1) Development
     - (2) Procurement & Collection
   - B. Process and Potable Supplies
     - (1) Treatment
     - (2) Distribution
     - (3) Conservation
2. Liquid Discharges
   - A. Collection, Treatment, Utilization, and Disposal
     - (1) Pulp Mill
       - (a) Pulping
       - (b) Bleachery
       - (c) Chemical make-up and recovery
       - (d) Woodyard
       - (e) Others
     - (2) Paper Mill
       - (a) White waters
       - (b) Others
     - (3) Domestic Sewage
3. Atmospheric Discharges
   - A. Collection, Treatment, Utilization, and Disposal
     - (1) Gaseous
     - (2) Particulate
     - (3) Vapors
4. Solid Residues
   - A. Collection, Treatment, Utilization, and Disposal
     - (1) Trash
     - (2) Bark
     - (3) Chemical processing residues
     - (4) Sludges
     - (5) Others
5. Receiving Waters
   - A. Self purification
   - B. Induced purification
6. Survey Techniques
   - A. In-Plant
     - (1) Flow measurement
     - (2) Sample collection
   - B. Receiving Waters
     - (1) Flow measurements
     - (2) Sample collection

SANITARY ENGINEERING COMMITTEE MEMBERSHIP

F. J. Coogan, International Paper Co., Southern Kraft Div., Mobile, Ala.
A. E. Dembitz, Singmaster & Breyer, Inc., New York, N. Y.
G. M. Griffith, West Virginia Pulp & Paper Co., Luke, Md.
J. M. Holderby, Lake States Yeast & Chemical Div., St. Regis Paper Co., Rhinelander, Wis.
G. C. Kimble, Union Bag-Camp Paper Corp., Savannah, Ga.
L. L. Klinger, Whippany Paper Board Company, Inc., Whippany, N. J., *Secretary*
N. J. Lardieri, National Council for Stream Improvement, New York, N. Y.
W. A. Moggio, Lake States Yeast & Chemical Div., St. Regis Paper Co., Rhinelander, Wis., *Chairman*
R. W. Simpson, Gilbert Associates, Inc., Reading, Pa.
C. V. Spangler, J. F. Pritchard & Co., Pittsburgh, Pa.
R. F. Weston, Roy F. Weston, Inc., Newton Square, Pa.

Fillers and Pigments Testing Committee

The meeting was called into session at 3:40 p.m., Aug. 18, 1959, in Portland, Ore., by acting Chairman Jerry Albert, with the following members and visitors present.

Yas Nomiyama, St. Regis Paper Co., Carthage, N. Y.
William F. Winkle, J. R. Simplot Co., Pocatello, Idaho
Gus A. Sporre, J. M. Huber Corp., Vancouver, Wash.
C. J. Allison, American Marietta Co., Seattle, Wash.
H. C. Brill, Du Pont-Pigments, Wilmington, Del.
Arthur M. Brooks, Columbia-Southern Chemical Corp., Pittsburgh 22, Pa.
M. P. Boland, Columbia Southern Chemical Corp., Barberton, Ohio
Bob Wood, Crown Zellerbach Corp., Camas, Wash.
C. G. Albert, Minerals & Chemicals Corp., Menlo Park, N. J.

The minutes of the last meeting at New York, N. Y., on Feb. 23, 1959, were read and accepted.

Mr. Albert reported on the results of 12 replies to the questionnaire on mineral testing (T 465). The majority of the replies were favorable. However, some disapproval was expressed on three of the test procedures. The objections were reviewed by the committee as follows.

1. Moisture. A sample size of 100 g. was felt to be too bulky by one of the questionnaire respondents. While it is felt that a 25-g. sample would be sufficiently large to give a precision of 0.05%, a larger sample may be desirable to give more representative sampling.

A task group will be assigned to investigate and to make recommendations on the most desirable sample size. Nathan Millman was recommended for the position of task group chairman.

2. pH. A 20% slurry was felt to be too thick for low density pigments. The consensus was that 10% would be more satisfactory and was recommended for inclusion in the omnibus mineral-testing procedure by Mr. Brill.

3. Grit. The term "325-mesh residue" was preferred to the term "grit" since such residue is often soft and friable.

The method of agitation of the pigment slurry prior to screening was open to question. The paint-shakers called for in the present method are not ordinarily found in paper mills and other methods of pigment dispersion should be investigated.

It was further suggested that the residue on the 325-mesh screen receive light brushing for the purpose of characterizing its softness and friability.

Fillers and Pigments Committee, Portland, Ore., August 18, 1959. Left to Right: A. M. Brooks, Columbia-Southern Chemical Corp., Pittsburgh 22, Pa.; C. G. Albert, Minerals & Chemicals Corp., Menlo Park, N. J.; Yas Nomiyama, St. Regis Paper Co., Carthage, N. Y.; W. F. Winkle, J. R. Simplot Co., Pocatello, Idaho; G. A. Sporre, J. M. Huber Corp., Vancouver, Wash.; C. J. Allison, American Marietta Co., Seattle, Wash.

The committee recommended that a task group be assigned to study these suggestions.

The status of projects assigned to different committee members was presented as follows.

No. 699. *Method for Calcium Carbonate*—George Hall. No report.

No. 700. *Method for Talc*—Maurice Warner. No report.

No. 701. *Method for Diatomaceous Earth*—Herb Kranich. A letter report and a proposed method were submitted. The proposed method, deleting the sections in common with the combined test method, will be submitted by letter ballot to the committee members.

No. 702. *Method for Calcium Silicate*—Nate Millman. No report.

No. 704. *Methods for Slurry Viscosity, Enzyme Compatibility, Adhesive Demands, Etc.*—Paul Plante (Reported by Yas Nomiyama). A proposed procedure for measuring viscosity of coating-pigment slurries was accepted and distributed to committee members for future comment.

No. 738. *Colored Pigments*—H. C. Brill. The scope of the committees responsibility must first be determined as to whether insoluble organic pigments will be included. To date tinting-strength evaluation has received the most attention.

A review was made of the seven TAPPI Standard methods under the jurisdiction of the Fillers and Pigments Committee.

T 615. *Analysis of Calcium Sulfate Fillers.* Last corrected in October, 1955. No further revisions proposed.

T 627. *Determination of Titanium Dioxide.* Revised in 1956 and corrected in 1958. No further corrections or revisions were proposed.

T 645. *Analysis of Clay.* Currently under extensive study as outlined above. An omnibus test method is in the process of preparation.

T 651. *Analysis of Highly Opaque Pigments.* Issued as a suggested method in 1957. Will be withdrawn when the omnibus standard is issued.

T 647. *Gross Particles in Coating Clay.* Issued as suggested method October, 1954. No revisions were proposed.

T 648. *Viscosity of Coating Clay Slurry.* Issued as suggested method in 1954. Will be modified by results of Project 704.

T 649. *Particle-Size Distribution of Coating Clay.* Issued as suggested method in November, 1954. No corrections or revisions were proposed.

T 646. *Brightness of Clay.* A report was submitted by Jerry Albert on the influence of sample preparation on clay brightness. The report emphasizes the importance of properly pulverizing the clay sample. However, paper mills normally do not have the required pulverizer equipment for sample preparation. An alternative procedure was submitted which involved the use of a Waring Blendor for pulverization.

It was recommended that this procedure be submitted to Jack Gunning for establishment as a routine control method prior to incorporation into the standard method.

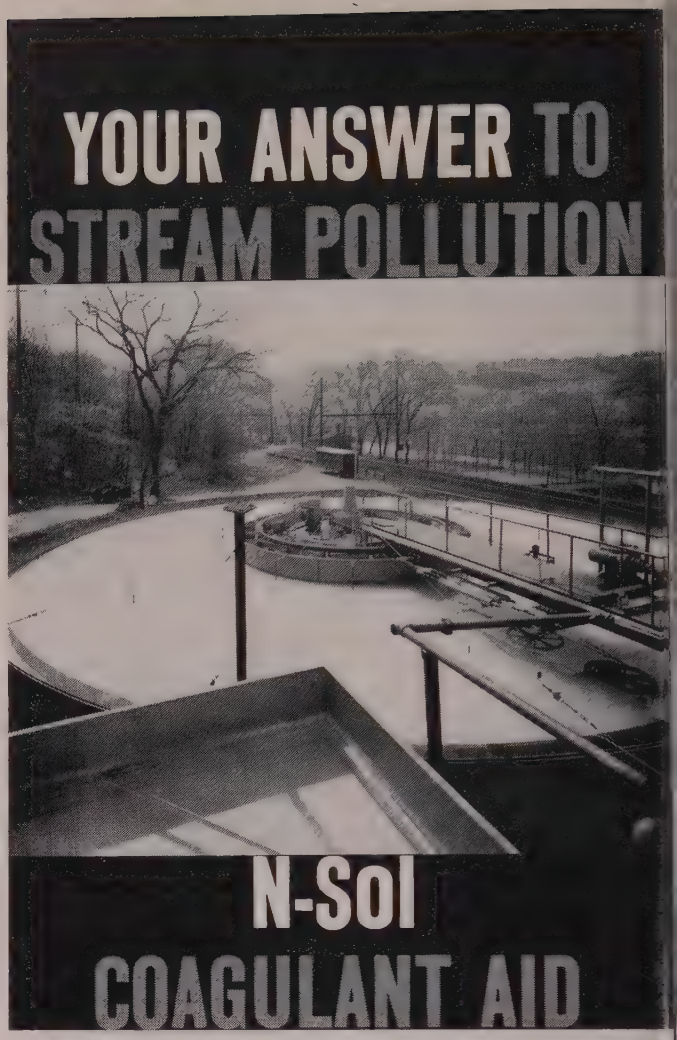
NEW BUSINESS

No new business was brought before the committee.

The session was adjourned by the acting chairman at 5:17 p.m.

Eleventh Coating Conference
Sponsored by the
Technical Association of the
Pulp and Paper Industry

Edgewater Beach Hotel, Chicago, Ill.
May 23–25, 1960



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ENGINEERING DIVISION

Overlay Repair of Alkaline Pulping Digesters Panel at the 14th Engineering Conference, Pittsburgh, Pa.

THE consideration being given to corrosion of carbon steel digesters in alkaline service was evident at the panel discussion on "Overlay Repair of Alkaline Pulping Digesters." The alkaline pulping industry is looking for a means to stop this expensive attack. Overlay appears to be the best solution to date. However, there have been some serious failures. This has rightfully raised questions in the minds of many of the mill personnel responsible for making the decision to use or not to use overlay. The purpose of this panel discussion was to present the history of overlay, the methods of installation, the metallurgical problems involved, and its service life—good and bad.

The panel members were: Zane Blanchard, Portland Copper Co., Portland, Me.; H. M. Canavan, Mutual Boiler and Machinery Insurance Co., Waltham, Mass.; E. G. Holmberg, International Nickel Co., New York, N. Y.; W. H. Parker, Hartford Steam Boiler and Insurance Co., Hartford, Conn.; Peter Zouck, Alloy Cladding Co., Baltimore, Md.; and L. Dela Grange of the H & D Division, West Virginia Pulp and Paper Co., Sandusky, Ohio. Mr. Dela Grange filled in for David Innes of International Paper Co., Mobile, Ala., who was unable to attend. The moderator was E. W. Hopper, chairman of the Corrosion Committee.

The panel brought out the results of the compilation of the digester inspection reports showing corrosion rates and the necessity for a means to reduce attack in order to extend digester life. The development of overlay as a means of extending this life was outlined together with an enumeration of the test results preceding its acceptance by the pulping industry and the insurance companies. The procedures used in installing the early overlay areas using manual arc welding was outlined together with the more recent installations of automatic welding using either the gas or flux shielding methods. The chemical and metallurgical tests on overlay coupons trepanned from digesters was discussed. Finally, the experiences of the Southern Kraft Div., International Paper Co., and West Virginia Pulp and Paper Co., the companies with the broadest experiences in overlay were presented.

Following the panel discussion, the meeting was opened up for general discussion. J. A. Goodford of Crucible Steel Co. showed pictures taken of overlay installations in digesters. These pictures illustrated digester overlays in good condition as well as those which had suffered minor to severe attack.

Photomicrographs, prepared from trepanned coupons of failed manual arc, gas shielded and flux shielded overlays, were shown by R. Timko and J. Naser of Jessop Steel Co. These showed several possible types of causes for failure. In one case the failures appeared to be due to attack in the weld metal directly at the boundaries between two beads. This attack penetrated deeply and sharply down to the base metal with all the attack parallel to and between the bead boundaries. In some cases this attack appeared to be heaviest in areas having a fine structure described by George Pease of International Nickel Co. as "chicken wire structure," as compared to the general columnar structure of the remaining weld deposit. Other failures, also developed parallel to the weld bead direction, appeared as sharp cracks which penetrated down to the base metal. Still other attack showed up as deep cracks transverse to the direction of welding. These transverse cracks normally were confined to one bead in width. They occurred at irregular intervals and appeared at the earliest inspection. They looked bad but on metallurgical examination seemed to have flattened and widened out without penetrating all the way to the base metal. In still other cases, individual beads were attacked, sometimes down to base metal, leaving beads alongside with only limited thinning. In most digesters, the areas which failed or showed severe attack were matched by adjacent areas which showed very little attack.

In those coupons which showed the sharp cracklike attack, the weld metal contained many microfissures and cracks which were plainly visible to the naked eye. In many instances the microfissures were well below the exposed surface of the overlay and did not appear to have contributed to the deep crevice attack.

Chemical analyses run by C. R. Carlisle of Jessop Steel Co. showed apparent dilution of stainless type 310 weld metal with the carbon steel base metal ranging from 28 to 30% in the case of manual arc overlay, to 55 to 60% in the case of the flux shielded.

The discussion brought out the fact that the early overlays installed from 6 to 9 years ago were all manual arc welded. Type 310 stainless, line coated rods of small diameter were used. Welding was slow and unhurried. Attempts were made to keep carbon steel dilution to a minimum and to prevent build up of temperature in the steel shell. The beads were well overlapped. Eight to ten pounds of rod were used per square foot to give at least an $^1/_8$ in. of weld metal coverage. Several coupons trepanned from overlay installed in 1951 were submitted for examination. These coupons were bright, shiny and showed no evidence of the slightest attack.

This procedure, even though slow, was accepted for the small areas ranging from 100 to 200 sq. ft. in extent. However, with the necessity for protecting areas of 400 sq. ft. up to the entire side wall of a digester, the down time required for slow manual arc welding was prohibitive. Manual arc overlay was speeded up using larger diameter electrodes but this was still too slow. In order to speed up the process and reduce costs, automatic welding was introduced; both gas and flux shielded. It was assumed, due to the excellent results to date, that stainless overlay was foolproof. The earliest automatic overlay installations proved the fallacy of this idea. Failure was rapid and thorough. It was reported that speeds up to 120 f.p.m. were employed with as little as $2^3/_4$ lb. of overlay applied per square foot. In many areas there were gaps between the individual beads as installed.

These plus some failures in manual arc overlays have shown the need for a thorough study of the subject. Among those present at the discussion were several welding engineers who outlined their thoughts on the subject. Several proposed that a weld deposit containing free ferrite be employed. It was suggested that a wire containing 28% min. chrome, 21% min. nickel, and $2^3/_4$% min. molybdenum be utilized. Limits on silicon were also suggested. It was the opinion of some of the committee members and guests that the deposit using this analysis would not develop microfissures and, therefore, would not corrode and fail. Several deposits utilizing this analysis are now being installed or are already in service These should start to give us answers to some of the questions still awaiting an answer.

The general opinion of the group was that dilution with

carbon steel was likely to reduce corrosion resistance and should be kept to a minimum, speed of welding should not be too high—a figure of 38 f.p.m. was mentioned as maximum. Weld beads should be overlapped and an 1/8 in. of overlay should be applied. In addition, more care in the preparation and cleaning of the steel base surface should be taken in order to allow for a better base for the weld metal.

It is unfortunate that the meeting did not produce a definite procedure which could be set down to govern all overlap applications and assure a life expectancy for the installation of 10 years or more. It is hoped that the discussion and recommendations made at the meeting will stimulate further constructive thought and technical study of this serious problem.

The tone of the meeting should show the pulp mill personnel the necessity for careful inspection of the welding operations during installation, following completion, and at the subsequent inspection periods. It should also show the installers of overlay the necessity for using all possible precautions in order to assure mills the best overlay installation that can be made.

It was stated by one panel member that failure of overlay only amounted to about 3% of the total area installed. Another panel member quoted 5 to 7% of the total area installed as having failed. These figures may have to be revised upward as some of the installations have only 6 months to 3 years of service life to date and in some cases show signs of attack already.

Overlay has shown itself to be a useful tool. It has also proved that it is not foolproof and that it can fail. It is up to the welding engineers and technicians the metallurgists, the appliers of overlay, and the mill operators to develop the answers to why overlay fails and how to prevent failure.

This subject has reached the stage in interest and importance where the Corrosion Committee feels that it should be handled as a subcommittee operating within the Corrosion Committee. This subcommittee will have Robert C. Stamm of West Virginia Pulp and Paper Co., New York, as its chairman and Walter Parker of Hartford Steam Boiler and Insurance Co., Hartford, Conn., as secretary. A number of applications have been received for membership and this subcommittee should have an interesting and important program.

E. W. Hopper

Note: The questions and answers will appear in subsequent issues of *Tappi*.

Questions and Answers

Good engineering questions are solicited as well as answers or alternate answers to the published questions. Material should be sent to TAPPI Headquarters, marked for the attention of H. O. Teeple. The items contributed will be forwarded to the Question and Answer Committee for processing. If comments are to be contributed, please refer to the question number.

R(5) *Question:* **Ten months ago we installed a 6 ft. diam. agitator impeller made of 1-in. thick, mild steel in our machine chest and have been operating it at a speed of 41 r.p.m. The outer 18 in. of this impeller have worn, washed, or corroded away leaving a rough, bumpy, and pitted surface. This has been a surprise to us for our stock is not abrasive nor particularly corrosive to mild steel. The hub of the impeller shows little corrosion. What material would you suggest to be used in a replacement impeller to inhibit this corrosion?**

(*5.2*) *Answer:* If the effects of cavitation are not too severe, it may be possible to effect a satisfactory repair by overlaying the affected area with stainless steel weld rod. The original contour of the impeller blades could be obtained by grinding the overlay.

R(37) *Question:* **Some years ago the TAPPI Electrical Engineering Committee published a report on cable practices and applications for the pulp and paper industry. This has some good dope in it, but now it's a little out-of-date. When are you going to bring it up-to-date?**

(*37.1*) *Answer:* The report referred to in this question was supplanted by TAPPI Data Sheet 157 which was issued in May, 1955. The Electrical Engineering Committee is presently reviewing this matter in order to update it, so that it can be reissued in 1960. The revised data will also reflect the results of the recently completed survey on the use of butyl cable in the pulp and paper industry.

R(44) *Question:* **Most magnetic starters drop out at 55 to 65% voltage and the voltage will dip whenever a fault occurs on an electrical distribution system. How do we keep vital equipment which is started by low voltage magnetic starters from dropping out when the voltage dips? Is there a standard time-delay undervoltage protection system available?**

(*44.1*) *Answer:* Manufacturers guarantee their a.c. starter to operate down to 85% of normal voltage. Below this point the starters may drop out or drop back at any value. The addition of time delay undervoltage protection will not prevent the contactors from dropping out. It functions to maintain the control circuit for a predetermined time usually 2 to 4 sec. If normal voltage is established within the setting of the time delay relay the starters will pick up.

To solve this problem there are four areas which should be investigated.

1. Time delay pushbutton station having a mechanical escapement mechanism which times out on loss of voltage.
2. A separate time delay system consisting of control relay, capacitors, rectifier and resistor. This system is expensive when used for small individual starters, is often used on large starter and groups of small starters.
3. Direct current operated (rectified a.c.) starters are available particularly in the larger sizes. They may be adjusted to hold it down to 35% voltage.
4. A latched contactor.

R(45) *Question:* **Are the electrical manufacturers going to make the old 60 in. deep medium voltage starters available for our industry to purchase?**

(*45.1*) *Answer:* Several manufacturers still offer the customer their choice of front or rear service medium voltage starters. The choice is with the user. Rear service starters with front service features such as gang operated disconnect switches and mechanical interlocks should be discouraged, since it adds complexity and maintenance.

*R**(52) *Question:* (Oil Grooves): **Is oiling aided by grooves in bearings?**

*R**(*52.1*) *Answer:* General opinion is that oiling is improved, providing the grooves are properly designed and cut.

Note 1: Questions and answers marked with an asterisk (*) are reproduced courtesy *Power* magazine.

Note 2: Questions or answers preceded by the letter (R) indicate that the material has been previously submitted by the Chairman of the Question and Answer Committee.

They should not be too deep or they will break the oil film, nor too shallow, or they fail of their purpose. They should not extend to the bearing edge, or will act as drains, and should not be cut in the lower bearing. Oil should be admitted at a minimum-pressure point if possible.

(*52.2*) *Answer:* As far as Question 52 is concerned, I should like to quote from page 113 of "Lubrication of Industrial and Marine Machinery" by the late William Gorden Forbes, John Wiley & Sons, 1948.

"Grooves are necessary in most bearings for evenly distributing the lubricant to all parts of the pressure area. However grooves in the actual pressure area are considered harmful because they tend to disrupt the oil film and reduce the size of this area.

The ability of an oil film to lift and support a heavy load is dependent upon hydraulic pressure. This pressure is brought about by the pumping action of the rotating journal, and any grooves in the pressure area which permit oil to escape will tend to encourage metallic contact. Also when bearings are composed of two or more parts fitted together, any sharp corners of the joints will tend to scrape the oil from the journal and, consequently, all corners and edges should be chamfered and rounded to prevent this scraping action."

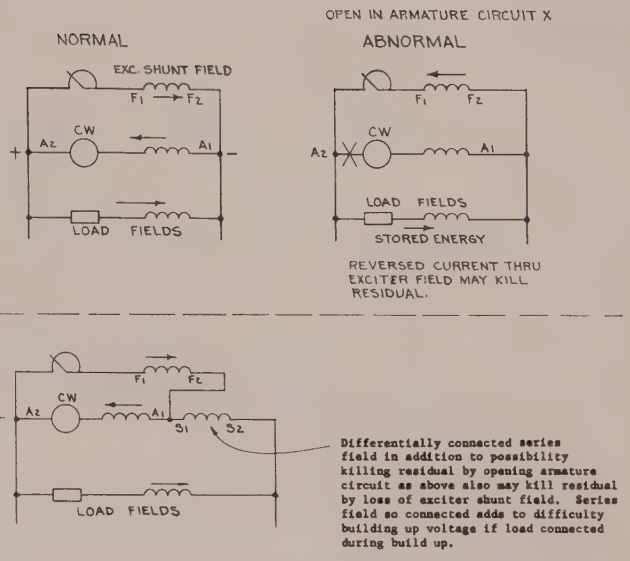
*R**(53) *Question:* **(Moisture in Transformer Oil): What is a simple method of testing transformer oil for moisture?**

R(53.1) Answer:* Anhydrous copper sulfate when placed in transformer oil will give a bluish tint if moisture is present. If small pieces of hot iron or nails are dropped into a sample of the oil the presence of moisture will be indicated by a hissing sound. Before applying either of these tests, it will be advisable to make the tests on samples known to contain moisture and others that are known to be "dry," to become familiar with reactions under both conditions.

(*53.2*) *Answer:* Since my company is very interested in blotting water from transformer oil, we have become familiar with the widespread use of electrical breakdown testers made by such firms as G.E. and Westinghouse to evaluate the amount of moisture in transformer oils. If these devices also answer this question satisfactorily from your point of view, perhaps it would be a favor to the questioner to point out that his friendly electric utility in all probability has such a device and can make tests upon oil samples very quickly.

(68) *Question:* **We have a self-excited rotating exciter supplying the field for several motors and generators and the control circuit on a variable speed multimotor rotogravure press. Several times in the past month this machine has come to a stop and the operators were unable to restart the machine. Each time, on investigation, it was found that the exciter voltage had dropped to zero. The exciter is rated at 6 amp. (1.5 kw.) and is fused with 10-amp. fuses. These fuses were not blown. All checks on the control circuit showed no shorts or grounds. The exciter itself checked out perfectly. By flashing the field on the exciter, it again builds up and continues to run for several weeks with no further trouble. What could be the cause of the trouble?**

(*68.1*) *Answer:* It seems possible for a self-excited generator supplying power to other generators and/or motor fields to lose its voltage and require its field to be flashed before it will build-up normally.


NORMAL
EXC. SHUNT FIELD
F1
F2
CW
A2
A1
LOAD FIELDS
OPEN IN ARMATURE CIRCUIT X
ABNORMAL
STORED ENERGY
REVERSED CURRENT THRU EXCITER FIELD MAY KILL RESIDUAL.
S1
S2
Differentially connected series field in addition to possibility killing residual by opening armature circuit as above also may kill residual by loss of exciter shunt field. Series field so connected adds to difficulty building up voltage if load connected during build up.

For instance, if while the exciter is carrying motor and/or generator fields as load something opened up the armature circuit inside the shunt field connection of the exciter the stored energy in the generator and motor fields would feed reversed through the shunt field of the exciter and may be of such magnitude as to leave insufficient residual to allow voltage build-up when the armature circuit is re-established. The most likely place for the armature circuit to become open and be intact when examined is at the brushes.

High resistance in the armature circuit, such as high brush contact resistance makes build-up of self-excited generator voltage more difficult or might require higher residual than if armature circuit resistance is low. High ohms in the shunt field circuit lessens the ability for build-up of a self-excited generator.

If a generator is operated on the unsaturated portion of characteristics it will not build up as readily as if operated on the saturated part of its characteristic, this is true if resistance in series with shunt field is unchanged from normal operating position.

If this self-excited generator has a series winding and it is connected differential to the shunt field, loss of shunt field while carrying load might also cause the residual to be so low as not to build up and if the exciter tries to build up with its load connected the reversed series field lessens its tendency to build up.

Loss of shunt field and remaking is most likely in rheostats or resistances.

An exciter with series field could also open its armature circuit inside shunt field connection and feed back of stored energy into exciter field kill residual and if series field reversed failure to build up under load more likely to be possible.

*(69) *Question:* **(Use of Flexible Coupling): Why is it necessary to employ a flexible coupling for direct connection of a motor and a centrifugal pump if both are mounted on the same baseplate?**

*(*69.1*) *Answer:* It is difficult to set the center of a centrifugal or other machine in true alignment with the center line of a motor, and still more difficult to maintain that alignment on account of difference in wear of the bearings. Hence, to obtain good running conditions when direct-connected, it is necessary to connect the motor to its load with a drag crank or some form of coupling that will adjust itself to the difference of alignment during operation.

Resin Solids in a Saturated Sheet

C. A. SICONOLFI

THIS project was established in the Plastic Laminates Committee with the objective of developing a test method for measuring total resin solids in a saturated sheet. The opinion has been expressed that a Kjeldahl analysis is sufficiently accurate for papers impregnated with melamine resin; straight phenolics, however, are generally subjected to Soxhlet extraction, with a variety of solvents used. Acetone and combinations of acetone, benzene, and alcohol have been tried with varying degrees of success.

Acetone extraction is useful to indicate possibly a change in cure, change in resin content of uncured specimens, change in type of resin used, or, the presence of plasticizers or other acetone-extractable agents. The amount of acetone-soluble matter is affected by: nature of resin and filler, lubricant, cure temperature, time of cure, technique of cure, and sample preparation, to mention but a few factors. It is quite obvious, therefore, that a more suitable method is required.

In its briefest form, the problem may be stated as a search for a suitable solvent with proper attention to details of the method. Such a search could be costly in terms of both delay and money for testing. For this reason, plastics industry representatives were approached in an effort to obtain more information as to solubility of fully cured resins.

At the Durez Laboratories, we are concerned with the examination of resins and molding compounds, principally phenolics. We have found that molten β-naphthol is a suitable solvent for uncured molding compounds and fully cured molded articles. Its efficiency, of course, depends to some extent on particle size of sample. When we suggested that the Plastics Laminates Committee consider the Durez Method for extraction of resin solids in fully cured laminates, we were promptly appointed to the task of finding out whether or not the method is suitable.

Knowlton Brothers has also reported the use of β-naphthol for this analysis. The principal difference between their method and that of Durez is the extraction time.

The following materials were used in this work:

1) 1/16 *in. XX Grade.* This is an alpha paper filled laminate with good electrical properties and low moisture absorption.

2) 1/8 *in. XX Grade.* (As above).

3) 1/8 *in. XP Grade.* This is a kraft paper filled laminate with unusual strength and resiliency.

4) 1/8 *in. CE Grade.* This has a coarse fabric base. The laminate combines toughness and excellent punching and machining qualities.

In addition, separate analyses were performed on the "blank" or untreated paper and cloth, both liners and fillers in each case.

Grateful acknowledgment is hereby made to the Spaulding Fibre Co., Tonawanda, N. Y., for kindly supplying the specimens used in this study.

C. A. SICONOLFI, Durez Plastics Division, Hooker Chemical Corp., North Tonawanda, N. Y. Plastics Laminates Committee, Project No. 764. Interim report.

EXPERIMENTAL

Sample Preparation. The blank papers and the impregnated papers were cut by hand scissors into small strips, approximately 1/4 × 1/16 in. Laminates were rasped with a metal file. All samples were conditioned at 45% R.H. in a desiccator containing a saturated solution of chromic acid. Generally, conditioning required not more than 48 hr.

Analysis. Approximately 3 g. of sample was accurately weighed (to 0.1 mg.) into a 300 ml., round bottom flask. Fifty grams of β-naphthol was added and an air condenser fitted on the flask.

The flask was placed in an electric heating mantle and voltage adjusted by a Variac to melt the naphthol and maintain a temperature of 165° ± 5°C. Temperature was checked by a thermometer in the well of the flask. Occasionally the flask with condenser attached was lifted out of the mantle and swirled to ensure dispersion of the sample in the molten naphthol.

Sublimation of naphthol, into the condenser, was controlled by occasional warming with a gas burner flame.

After the prescribed heating period, the flask was cooled and 250 ml. of denatured alcohol (SD no. 3) was added. The contents were then gently refluxed (water condenser) until the cake was completely broken up, generally 5 to 10 min. The cooled solution was then filtered quantitatively by vacuum through a previously weighed sintered glass crucible of medium porosity. The residue was washed with fresh alcohol until a colorless filtrate was obtained, finally by acetone (about 100 ml.), air-dried, by maintaining vacuum for 15 min., and then placed in a 105°C. oven for 2 hr. Finally, the crucible and residue was placed in the 45% R.H. desiccator and allowed to come to constant weight.

The resin content was calculated by the formula:

$$\% \text{ Resin} = \frac{(\text{Sample weight} - \text{Residue weight} \times 100)}{\text{Sample weight}}$$

Acetone Extractions. For purposes of comparison, acetone extractions of all samples were made following essentially the method prescribed by ASTM D 494–46 (Table I).

Table I. Per Cent Extracted

	Acetone, 16 hr.	*β-Naphthol*		
		3 hr.	*8 hr.*	*24 hr.*
1/16" XX[a]	4.2	48.5	..	48.6
B-Stage filler	34.1	35.3	38.8	..
B-Stage liner	67.5	69.2	68.9	..
Paper filler	0.9	1.3	1.3	..
Paper liner	0.9	1.3	0.8	..
1/8" XX[a]	4.8	43.2	..	43.1
B-Stage filler	35.3	37.7	38.3	..
B-Stage liner	67.5	69.2	68.9	..
Paper filler	0.9	1.3	1.3	..
Paper liner	0.9	1.3	0.8	..
1/8" XP[a]	9.6	48.5	..	48.5
B-Stage filler	37.0	39.7	39.5	..
B-Stage liner	45.9	47.8	48.5	..
Kraft paper	0.6	1.9	1.0	..
1/8" CE[a]	0.1	58.3	..	61.3
B-Stage filler	51.9	53.6	53.6	..
B-Stage liner	54.7	56.8	57.0	..
Fabric	1.8	3.6	3.7	..

[a] NEMA grades.

DISCUSSION

The data observed are presented in Table I. Examination of the figures reveals the following:

1) Acetone extraction is probably suitable for measuring resin content of the B-stage materials. However, caution must be advised in this respect since these data were concerned only with a single phenolic resin. It has been the experience of the author that some phenolics, particularly among the one-step types (resoles), will gel when acetone extraction is attempted. In such cases, examination of the residue will immediately tell whether gelation, and consequent incomplete extraction, has taken place.

2. Under the conditions of test, β-naphthol extraction is essentially complete in 3 hr. No significant differences were observed between 3- and 24-hr. extractions of the finished laminates, nor between the 3- and 8-hr. extractions of the B-stage materials.

3. The significance of the acetone extraction of finished laminates is open to question. Whatever was extracted could have been volatile matter in the product, low molecular weight resin or some such component.

4. The numbers generally are reasonable since it is to be expected that the resin content of the finished product will lie somewhere between the high value obtained for the liner and the lower value for the filler. With the exception of the cloth filled material, such has been found to be the case.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the data obtained here, it is concluded that the proposed method is worthy of further investigation. It is recommended that the Plastics Laminates Committee proceed with a round-robin program, to establish the precision and, if possible, the accuracy of this method.

The Assistance of R. J. Siudzinski, who ran all these analyses in the Durez Analytical Research Laboratory, is gratefully acknowledged.

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E488-60. Chemical engineer desires position in management with opportunity for advancement. Ten years experience as plant chemist manufacturing boxboard and medium. Experienced in quality control, technical service and carton converting.

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(P957-60)

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(P973–60)

Reducible Sulfur in Paper and Paperboard

Revision of TAPPI Standard T 406 m-53–Reclassified as a Tentative Standard

(THIS STANDARD IS UNDER THE JURISDICTION OF THE CHEMICAL METHODS COMMITTEE)

THIS method is for determining the total reducible sulfur in paper, but is not necessarily a measure of how much a given paper will tarnish silverware. When tested by this method, paper which has less than 0.0008% reducible sulfur, may be assumed to be non-tarnishing as far as sulfur is concerned but if more than 0.0008%, this does not necessarily mean that tarnishing will occur, since sulfur compounds which may not cause staining are reduced by the treatment with the subsequent evolution of hydrogen sulfide. If more than 0.0008% reducible sulfur is found, or if the effect of that or other materials causing stains on silver is desired, the paper should be subjected to an accelerated tarnishing test (see TAPPI T 444 m).

Because this is a very sensitive test method, and the quantities of sulfur sought are so small, great care must be taken to avoid possible contamination of the reagents and specimens by contact with the bare fingers, or from minute quantities of sulfur compounds being absorbed from the air. Consequently, even if a day elapses between tests, it is advisable to make a blank test with the same apparatus, liquids, and materials to be used for the actual test, to make sure that they do not contain, nor have acquired, any appreciable quantity of sulfur.

APPARATUS

1. *Reaction Apparatus:* consisting of a 100-ml. extraction flask carrying a short, water-cooled condenser (see Fig. 1). Over the condenser is placed a flanged head containing a disk of filter paper impregnated with lead acetate. The condenser prevents water vapor from condensing on the test paper which would cause an uneven development of the spots.

2. *Buret or Pipet:* 1 ml., graduated in 0.01-ml. divisions.

3. *Other Equipment:* water bath at 100°C. or steam bath, to heat the reaction flask; 50-ml. beaker and glass stirring rod with flattened end; 100-ml. and 1-liter volumetric flasks; 10-ml. pipet, and clean forceps for handling the specimens.

REAGENTS

A. *Aluminum Foil:* not over 0.01 in. thick, or crushed stick zinc, sulfur free.

B. *Phosphoric Acid:* concd., (85%) H_3PO_4, reagent grade, sulfur free. It is advisable to treat the acid with bromine water and heat until all excess bromine is expelled.

C. *Sodium Thiosulfate:* standard solution not over two days old. Use recently boiled distilled water cooled to about 20°C. for preparing the solution. Dissolve 0.097 g. of reagent grade, fresh, clean crystals of $Na_2S_2O_3 \cdot 5H_2O$ in a little water in a 100-ml. volu-

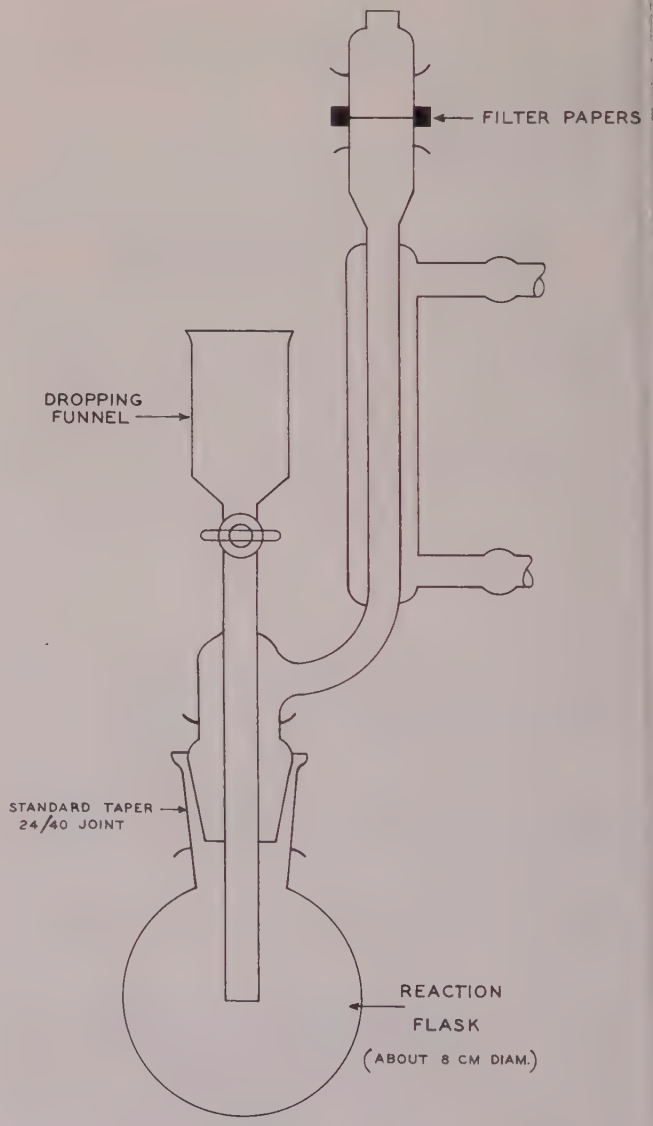

Fig. 1. Apparatus for reducible sulfur

metric flask, dilute to the mark and mix thoroughly; then dilute 10 ml. of this solution to 1 l. and mix thoroughly. One ml. of this diluted solution contains the equivalent of 0.0000025 g. of sulfur.

D. *Lead Acetate:* 20% solution, Pb $(C_2H_3O_2)_2 \cdot 3H_2O$, reagent grade.

E. *Test Paper:* fresh, high quality, rapid filtering grade of filter paper untouched with bare fingers and impregnated with the lead acetate solution, dried and cut into 1-in. diam. disks and to be kept stored in an air-tight container. Cut also 1-in. diam. disks of the unimpregnated paper to clamp beneath each test disk so as to prevent any acid spray decolorizing the darkened areas. Just before use, pick up a disk of the test paper with clean forceps, moisten with a minimum of distilled water, and lay it on a dry, unimpregnated disk ready to go into the apparatus.

TEST SPECIMEN

For each test specimen cut pieces of paper about 6 mm. (0.25 in.) square from representative sample sheets, and weigh the equivalent of 0.25 ± 0.005 g. of moisture-free paper. (Determine the average moisture content of the samples if it is not known to within 1%.) For papers which are low in sulfur, increase the weight of the test specimen preferably to 0.5, 0.75 or to a maximum of one gram. Do not touch the areas of the samples to be tested with the fingers; handle with clean forceps only.

Note: Tightly wrap any samples that are to be stored or shipped in individual lots, in sulfur-free aluminum foil.

PROCEDURE

By means of the forceps, transfer the weighed specimen to the flask. Add a few milliliters of distilled water and macerate the paper by means of a clean, glass stirring rod until it is thoroughly soaked and at least partially disintegrated. Wash down the glass rod with a few milliliters of distilled water until the total volume in the flask is about 20 ml. Add 2 g. of aluminum foil cut into small pieces. Attach the condenser, the funnel, and the head containing the disk of lead acetate paper with the plain paper disk beneath, to the flask. Through the dropping funnel, add 10 ml. of H_3PO_4 and close the cock. Heat the flask and contents on the water bath. After 45 min. remove the apparatus from the bath, take out the lead acetate disk, compare it with the set of disks stained with known amounts of sulfur prepared as described below, and estimate the amount of sulfur evolved by the specimen.

Prepare the set of stained disks by using exactly the same procedure and chemicals as described, but in place of the test specimen, from the graduated pipet or buret, add measured amounts of the standard $Na_2S_2O_3$ solution such as 0.1, 0.2, 0.4, 0.6, 0.8, and 1.0 ml., respectively. This will give a range suitable for most papers. One milliliter of this solution contains the equivalent of 0.001% sulfur in a 0.25-g. specimen.

Before each series of test, make a blank test using the same amounts of water, acid, and aluminum foil as used in the procedure, but without any additive. The resulting stain should be barely perceptible; otherwise purify or replace the reagents or clean the equipment.

REPORT

Report the amount of reducible sulfur as a percentage by weight of the moisture-free paper, to two significant figures.

ADDITIONAL INFORMATION

This revision is extensive; the equipment is modified and simplified and the results are reported on a moisture-free basis.

A modified colorimetric method, comprising the reduction of the sulfur to hydrogen sulfide and reaction with p-aminodimethyl aniline to form methylene blue, has been described (*1*) n. b. This method will be considered in a subsequent revision of the method when additional correlative data are obtained.

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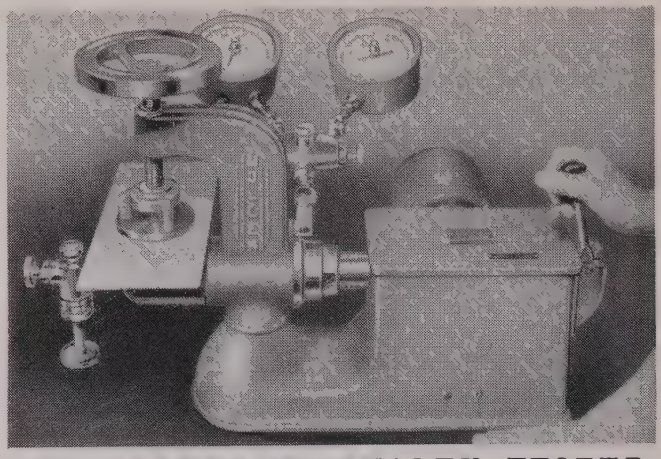

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ROUTINE CONTROL METHODS

RC-275. Testing of Alkaline Product Discoloration on Printed Packaging Materials

This test is to determine the effect of alkaline materials on printed packaging materials such as paper, wrappers, labels, liners, containers, etc. Examples of alkaline materials which may adversely affect printed packaging materials are: cement, detergents, lye, soap, soap powders, etc. Such substances may cause discoloration of the packaging materials or discoloration of the printed matter because of the alkaline nature of the packaged product. The test will give an indication of the possible effect of the alkaline substance on the printed package at the point of use of the printed packaging materials.

Scope and Purpose

The alkaline product test is a spot reaction test to produce rapidly an indication of the susceptibility of a printed package to alkaline contents or substances with which it may come in contact. It does not, however, replace the six-month storage test which, for safety, should always be carreid out, even when the results of the quick Alkaline Product Test show that the printed package is presumably safe from discoloration by the product.

Apparatus

1. Four clean graduated glass cylinders, 5 ml. or 10 ml., graduated to milliliters and tenths of milliliters.
2. Clean medicine droppers.

Chemicals

Standard saturated solution of material to be packaged or tested. This method preparation will be dependent on type of material involved.

For use in the tests, this solution is to be diluted in small quantities by means of the graduated cylinder as directed below.

To prepare 50% solution, add an equal volume of water to saturated test solution in the graduated cylinder. Mix by shaking.

To prepare 25% solution, add 3 volumes of water to one volume saturated solution in the graduated cylinder. Mix by shaking.

To prepare a 10% solution, add 9 volumes of water to one volume of saturated solution. Mix by shaking.

Prepare fresh dilutions for each day's work.

Preparation of Test Specimen

Place the material to be tested on a flat, clean surface. Mark off several areas with a lead pencil so that each area will include a portion of each kind of ink or color and some of the unprinted paper if any of the latter is exposed.

Procedure

1. Make up either 5 or 10 ml. of 50, 25, and 10% strength alkaline product, as directed under Chemicals.
2. Mark each area with the strength of the product solution to be used for testing it. Apply 1 drop (0.05 ml.) of product solution of the corresponding strength to each different kind of ink and to the unprinted paper. Do not spread the drop. Avoid moving the paper during the test.
3. Test each area in turn with (50, 25, and 10%) product solution. Use a separate, clean medicine dropper for each dilution. To identify the spots where drops of product have been placed, indicate their location by penciled arrows pointing toward the drops. Allow the paper to remain undisturbed at room temperature and humidity for 10 min. or until the drops have dried, whichever is sooner.

Examination of Tests

After the product drops have been allowed to dry on the papers, observe carefully the effect of the different strengths of product solution on each color and on the unprinted paper.

1. Note with respect to each strength of product and each color, whether the product has produced an undesirable or harmful change.
2. Observe also the reverse side of the paper to determine if product has come through from the side on which the test was made.
3. Note also whether any of the colors have bled through from the printed side.

Report for each strength of solution:

1. No discoloration or change of each color tested, or
2. Slight discoloration or change of each color tested, or
3. Pronounced discoloration or change of each color tested.

Also report:

4. Penetration of paper by the product.
5. Bleeding of colors.

Interpretation

This alkaline product test can also be used to determine whether various protective coatings, such as vinyl lacquers, will withstand at least a 25% solution of the product. If no blistering of the coating, or discoloration of the back of the wrapper occurs, then the coating is satisfactory for packaging materials.

This procedure is similar to the Packaging Institute's tentative procedure for "Testing Effect of Alkali on Various Types of Printed Packaging Materials" (1954).

This is a Routine Control Method and should not be considered as a Standard in any way. Corrections may be made before loose-leaf publication. Comments will be welcomed and should be sent to A. J. Winchester, TAPPI, 360 Lexington Ave., New York 17, N. Y.

RC-276. Forming Handsheets for Physical Tests of Pulp for Corrugating Medium

This describes a method of forming test sheets from refined pulps which are to be used in corrugating media. It is applicable only to slush pulps and is designed for the preparation of test sheets with a basis weight in the range of mill corrugating medium. The following example gives conditions for the formation of sheets equivalent to 26 lb. per 1000 sq. ft.

Equipment

TAPPI sheetmaking equipment, apparatus for measuring consistency, and a three-bladed propeller-type mixer with a speed of 1750 r.p.m.

Sample Preparation

Collect a representative sample of pulp. Moist pulp samples should be stored in a cool place under water with a few drops of formaldehyde. Dilute a portion of the sample equivalent to 18 ± 0.5 g. ovendry fiber to 6 l. with water at 23 ± 2°C. Disperse the pulp thoroughly and determine its consistency.

Sheetmaking

Prepare handsheets as in TAPPI Std. T 205 m-58, with the following exception. Pour a quantity of dilute stock equivalent to 2.54 g. of ovendry stock into the sheet mold, instead of the 800 ml. quantity called for in T 205 m-58. Use proportionate quantities of stock for forming sheets of other weights.

Couching, Pressing, and Drying

Couch, press, and dry the sheets in accordance with TAPPI Standard 205 m-58, with the following modifications when necessary.

Couching Difficulties

If sheets are to be made from very free stock, difficulty may be experienced in removing the sheet from the wire after couching. This can be overcome by stretching a single layer of cheesecloth (no. 70) across the wire grid before closing the sheet machine. The cheesecloth should be thoroughly wet and the surface above the wire must be wrinkle-free. Normal sheetmaking procedure is then followed. After couching, the sheet and blotters are carefully peeled from the cheesecloth to avoid displacement of fibers. The imprint of the cheesecloth on the sheet becomes indistinguishable on pressing.

Obtaining Desired Caliper

For many purposes, especially if the sheets are to be tested by fluting, it is desirable that they be very near 9 pt. in caliper. With the wide variety of stocks that are used for corrugating media, many of which are relatively coarse, there will be many instances when the sheets made by the method above will be considerably thicker than 9 pt. In such cases, it will be necessary to reduce the caliper to the desired level by pressing at a considerably higher pressure or by calendering. At one mill, in order to obtain a caliper of about 9 pt. in the middle freeness range (750 to 550 ml., Schopper-Riegler, 2 g.), it has been found necessary to apply a pressure of 1200 p.s.i., or a total force of about 37,000 lb., to the standard handsheet.

Rapid Drying

In many cases a much faster drying method is desirable. It has been found that the hot-plate drying described below is entirely satisfactory for this purpose. Sheets dried in this manner have a slightly lower flat crush than airdried sheets, but the precision of Concora crush tests is the same on the hot-dried and the airdried sheets.

Remove the stack from the press and place each plate with its sheet, sheetside down, on a dry blotter. Place each individual stack (containing only one plate, sheet, and blotter) in a rapid drier of the heated plate-unheated cover type with the blotter next to the heated surface. Allow to dry for 10 min. at a temperature of 290 ± 10°F. Remove sheets from the drier and condition according to TAPPI Standard T 402 before testing.

Submitted by: R. Chase, *Union Bag-Camp Paper Corp., Savannah, Ga.*

This is a Routine Control Method and should not be considered as a Standard in any way. Corrections may be made before loose-leaf publication. Comments will be welcomed and should be sent to A. J. Winchester, TAPPI, 360 Lexington Ave., New York 17, N. Y.

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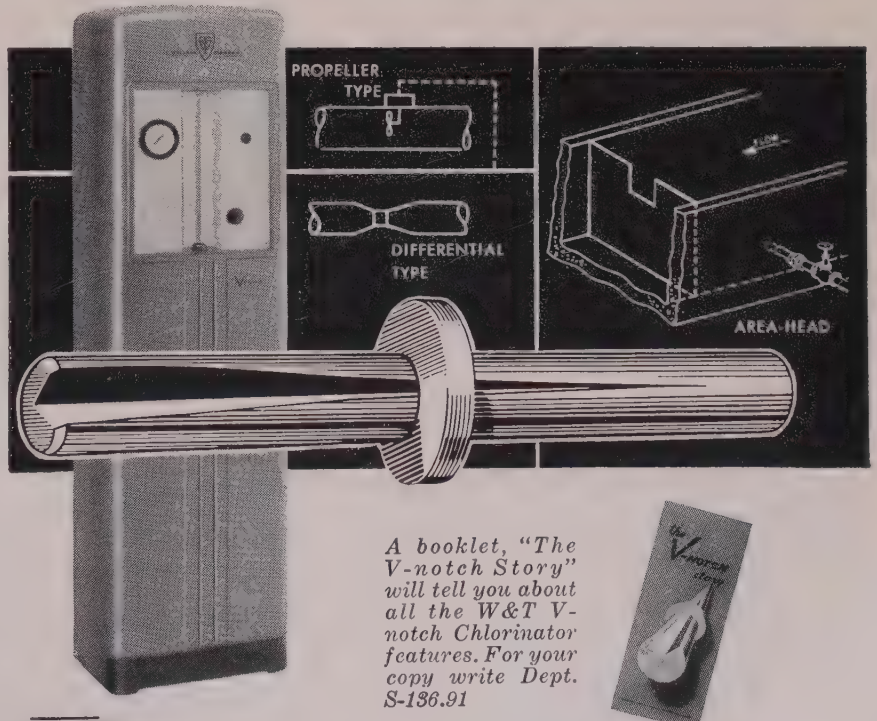

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LOCAL SECTION ACTIVITIES

Meeting Calendar

March, 1960

26 Delaware Valley Section, Benjamin Franklin Hotel, Philadelphia, Pa., 1960 Philadelphia Graphic Arts Conference.

29 Golden Gate District—Pacific Section, "Recent Advances in Materials Handling," 4:00 p.m., mill visit to Nulaid plant. Dinner at Cottage Restaurant, San Leandro, 6:00 p.m.

April, 1960

5 Chicago Section, Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill., "Corrugating."

8 New England Section, Management Night.

12 Ohio Section, Miami University, Oxford, Ohio, tour of the new Paper School. Subject: "High Polymers." Speaker: H. E. Whiteacre.

12 Lakes States Section, dinner, location to be announced, C. J. West Awards.

12 Empire State Section—Metropolitan District, "Packaging."

14 Empire State Section—Northern District, Junior Award Night.

19 Ohio Section—Indiana District, plant tour to be announced, "Coating." Speaker: Brag Golding, Purdue University.

21 Empire State Section—Eastern District, Symposium, "Wet End Machine Operation."

21 Kalamazoo Valley Section, Inman's Restaurant, Galesburg, Mich., "Stock Preparation."

26 St. Louis Section, Le Chateau, St. Louis, Mo. Charter Presentation.

28 Delaware Valley Section, Engineers Club, Philadelphia, Pa., E. J. Albert Award Program.

28–30 Pacific Section, Bellingham, Wash., Annual Meeting.

May, 1960

3 Chicago Section, Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill.

10 Pacific Section—Golden Gate District, Hotel Claremont, Berkeley, Calif., True Memorial Lecture.

12 Kalamazoo Valley Section, Harris Hotel, Kalamazoo, Mich., Recognition Night, WMU Awards.

12 Empire State Section—Northern District, Annual Ladies' Night.

12 Ohio Section, Hartwell Country Club, Cincinnati, Ohio, Ladies Night.

13 Gulf Coast Section, Jung Hotel, New Orleans, La.

13 Empire State Section—Metropolitan District, Ladies' Night.

17 Ohio Section—Indiana District, Marott Hotel, Indianapolis, Ind., "Testing." Speaker: Arthur Dreshfield, The Glidden Co.

20–21 Virginia-Carolina Section, Wilmington, N. C., mill visit to Riegel Paper Corp., Acme, N. C.

20–21 Southeastern Section, Savannah, Ga.

21 Empire State Section—Eastern District, Annual Ladies' Night.

27 Delaware Valley Section, Beloit Eastern, Downingtown, Pa., tour and outing.

June, 1960

3–4 New England Section, Chatham Bars Inn, Chatham, Mass., Spring Meeting.

10–11 Empire State Section, Whiteface Inn, Whiteface, N. Y., Annual Meeting.

17–18 Maine-New Hampshire Section, Mountain View House, Whitefield, N. H., Annual Meeting.

21 Kalamazoo Valley Section, Annual Golf Outing, Gull Lake Country Club.

September, 1960

21 Pacific Section, Salem, Ore., "Modernization."

Chicago

The following talk was delivered at the December meeting.

Implications of the Recent Food Additive Amendment—As It Applies to Food Packaging Materials

John H. Guill, Jr.

I AM glad to be here this evening to explain to interested people the law and its application.

Before delving into the depths of the specific subject matter, I want to give you a brief sketch of the law and the organization charged with its enforcement.

In the years between the Spanish-American War in 1898 and 1906, there was considerable agitation on the part of the public and Dr. Harvey W. Wiley of the USDA Bureau of Chemistry, for a National Pure Food and Drug Law. This was successful and such a law became effective in 1907.

Many shortcomings developed over the years. A new law was proposed in 1933. Controversy arose over various provisions affecting industries; considerable opposition was set against the proposed requirements for the pretesting of drugs.

In 1937 a new treatment for venereal diseases and other infections was produced and distributed widely through the south and central states. It was composed of sulfanilamide powder dissolved in diethylene glycol. The solvent was untested by the manufacturer although it had been reported in scientific periodicals to be toxic. It disrupted the function of the kidneys of many users and killed more than 100 people.

Passage of the new law, the Federal Food, Drug, and Cosmetic Act, with its pretesting of new drugs requirement ensued during the next session of Congress. This law had sections relating to health which were effective on signature, June 25, 1938, it became fully effective a year later except for a few specific extensions. Coal tar colors used in foods, drugs, and cosmetics were required to be certified.

In 1941 insulin certification became a requirement. Toward the end of the war penicillin certification was enacted; four other antibiotics and their derivatives were added to the certification list later in the 1940's.

In 1952 the courts held invalid the provision which we interpreted as permitting factory inspection. Within 7 months Congress clarified this section of the Act, restoring forthrightly the FDA's right to inspect premises where foods,

JOHN H. GUILL, JR., Chief, Chicago District, Federal Drug Administration, Chicago, Ill.

etc., were manufactured, stored, or transported. Responsibilities were placed on the Government to:

Issue Notice of Intent to Inspect.
Give receipt for samples.
Give written report *re* unsanitary conditions.
Report results of analysis for filth.

In 1954 the Pesticide Amendment was passed.

In 1955 the operations, goals, methods, and personnel of FDA were studied by a body of 13 distinguished citizens. In most of the report of this committee it was in accord with the organization's aims, however, it found FDA to be woefully understaffed to do the job in the depth and breadth the committee felt was necessary. Therefore, it recommended a three to fourfold expansion in personnel over a 5 to 10-yr. period. At that time the total of people employed was just under 1000. Now it is approaching 1600. The 1960 budget provides for 1660. Quite a few positions for inspectors and chemists, and other scientists, are open.

Nearly two thirds of these people are outside of Washington, located in 17 district offices with an 18th to open soon. About 400 of these field employees now on the staff are inspectors; 300 are chemists, and the rest administrative or clerical, or supplemental support to laboratory operation.

An important development in this sketch of the history of the law was the signing of the Food Additives Amendment on Sept. 6, 1958.

Previous to this addition, new materials could be added to foods without adequate testing. It was the responsibility of the FDA to develop methods, isolate, identify, and prove their toxicity before successful legal action could be brought to stop the use of these materials of unknown effect. The Amendment places immediate responsibility on the shoulders of the shippers of foods containing new materials or old materials not generally recognized as safe by qualified experts to establish the safety of the material for the proposed use. To use an unsafe food additive as defined in the amendment will result in adulteration of the food with possible action against the shipper as well as appropriate confiscation of the shipment. The injunction provision of the Act could be used to prevent interstate shipments of such adulterated food.

What is a food additive—ordinarily you would say anyone knows, it is something added to a food. Not so, legally—unfortunately, in order to be specific, to include those materials intended to be included and exclude those not intended to be covered, the legal definition is cumbersome. It reads:

> "The term 'food additive' means any substance the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food; and including any source of radiation intended for any such use), if such substance is not generally recognized, among experts qualified by scientific training and experience to evaluate its safety, as having been adequately shown through scientific procedures (or, in the case of a substance used in food prior to January 1, 1958, through either scientific procedures or experience based on common use in food) to be safe under the conditions of its intended use; except that such term does not include—
>
> (1) a pesticide chemical in or on a raw agricultural commodity; or
>
> (2) a pesticide chemical to the extent that it is intended for use or is used in the production, storage, or transportation of any raw agricultural commodity; or
>
> (3) any substance used in accordance with a sanction or approval granted prior to the enactment of this paragraph pursuant to this Act, the Poultry Products Inspection Act (21 U.S.C. 451 and the following) or the Meat Inspection Act of March 4, 1907 (34 Stat. 1260), as amended and extended (21 U.S.C. 71 and the following)."

Gentlemen, there are only a few days more than 4 months remaining before this law becomes fully effective. If little or nothing has been done since passage of the amendment, it may be too late to continue to use some components of your packaging materials after March 6, 1960.

Deputy Commissioner Harvey said in October of this year:

> "By far the greater amount of uncertainty as to where to take hold of the problem has existed in the container field. Many questions have been asked about the responsibility and liability of the various producing factors involved in getting containers on to the market containing the foods. Very naturally, each person involved has been hopeful that he could receive from the man back of him some magic piece of paper which would absolve him from whatever responsibility the law might otherwise impose upon him. Many of the containers start as trees or other forms of potential pulp. Some of them start as wastepaper. These progress through the manufacturing processes and eventually become paper boxes containing food. Many different chemicals are used in converting organic materials into paper and cardboard, and merely compiling a list of these and looking at it from the standpoint of any of them becoming components of the food is disheartening.
>
> "We have sought to alleviate the unwarranted fears in the container industry and among container users to every extent consistent with the facts of life. We have emphasized that it is not that which goes into the package, but that which goes into the food that is the concern under the amendment. We have recognized the impracticability of tracing possible migration of packaging components into every food which may be used to fill containers. We have done our best to develop and recognize more or less standard methods for testing migrations. We have introduced the principle of simulated solvents, and we have applied such ingenuity to the problem as we have been able to apply, always keeping in mind that the paramount question must be resolved before we can issue a regulation or sanction an exemption. The paramount question is 'whatever happens under the circumstances of intended use, is the food product safe for human consumption?'
>
> "I am sure that we have been accused of arbitrariness and unreasonableness on more than one occasion. It is possible that there is some justification. On the other hand, I am well aware of the fact that we have foregone enumerable opportunities to appear unreasonable, because it has been my task largely to resolve as best I could many of the perplexing questions. It has been and will be my view that when it can be resolved to retain the paramount consideration intact that the product be safe, there must always be a way to resolve the other questions incident thereto."

Mr. Arthur A. Checchi, formerly of our Commissioner's office, advised recently as follows:

> "To establish the status of a food package under the Amendment, one should undertake immediately to conduct extraction studies on it to determine what, if anything, migrates from it to food under the intended conditions of use. There is little point in trying to establish the status of packaging materials under the Amendment without first having developed the extraction data. Unless you have gone over these procedures with the Food and Drug Administration in the past, we suggest you get together the technical information regarding the composition, production and proposed use of the material to be tested; then, come to Washington and discuss extraction methods. We may be able to save you both time and money.
>
> "Once the extraction studies are completed, you will find yourself confronted with one of two possibilities. There may be no expected migration of any substance to food. If so, the packaging material you have tested is not subject to the Amendment, except in the unlikely event that it otherwise affects the characteristics of the food contained in it."

(At this point, the Federal Register of November 20 listing the 182 substances generally recognized as safe within the meaning of Sec. 409 of the Act was displayed.)

I want to call to your attention the fact that not all of the substances listed in the Federal Register of Dec. 9, 1958, were generally recognized as safe. The six substances which failed to receive this recognition are: carbon black, charcoal, oleic acid, linoleic acid, titanium dioxide, ultramarine blue.

(The following is a continuation of Mr. Checchi's statements.)

> "Where migration is detected, the quantity, and to the extent possible, the identity of the migrant should be established. When this has been determined, you once again face one of two possibilities. If the migrant in the quantity detected is one which is generally recognized by appropriately qualified experts as safe in the food in question, or is one that has already been approved for such use (at this point the speaker

advised the group to see the Federal Register just called to their attention), then it, and once again the packaging material from which mitigrates, is not subject to the Amendment, and no further work is necessary. Where the migrant is not one that is generally recognized as safe or otherwise not excused from the clearance provisions of the Amendment, its safety for its intended use must be established in accordance with the procedures laid down in the law.

"These procedures have been discussed many times in public meetings of this type. Therefore, I shall not take the time to go into them now. However, if any of you would like more information in this regard, we shall be glad to furnish it upon request. Likewise, if anyone would like to receive information on the extraction procedures which we regard reliable, we shall be happy to accommodate you.

"Once you have conducted extraction studies and isolated a migrant, if there is any question in your mind as to whether it is one which requires further proof of safety, furnish us with facts and we'll be glad to offer an opinion as to whether additional work is needed. Please don't ask us whether any substance is an acceptable component of food packaging material without at the same time telling us how much, if any, migrates to food. It is unlikely that in most such instances we will be able to furnish you with a satisfactory answer. We'll probably advise appropriate extraction studies.

"The sooner extraction studies are made of existing food packaging materials, and the results evaluated, the sooner any doubts surrounding their status under the Amendment can be resolved. Thus, we urge that those of you who have not already done so, get on with this work. Depending on the results, it is entirely possible that once the facts are known, any problems they present can be dealt with with ease. For example, if it is found that one of the migratory substances requires proof of safety before it can be permitted, it is entirely possible that another whose safety has already been established can be substituted for it satisfactorily in the fabrication of the packaging material.

"I think that one of the points that has caused most concern in the industry has been the requirement that practicable methods of analysis for determining quantitatively and qualitatively the residues of food additives in or on food must be submitted as part of a petition under the Amendment. We have said repeatedly and will continue to take the position that we will resist issuing any regulation intended to assure the safe use of a food additive unless there is a practicable means for enforcing it. We recognize full well that despite the impressive advances in the science of analytical chemistry, especially in recent years, chemists still do not have available to them adequate techniques and scientific tools that will always demonstrate the identity and quantity of a substance that has been added to a food. This is perhaps particularly true when we are concerned with items which migrate from food packaging containers in quantities of a few parts per million and less. Nevertheless, these minute quantities may well be of toxicological significance, and their presence in food must therefore be carefully controlled.

"Now, rather than to throw up our hands in despair in the face of the problem, let us examine some of the alternatives to precise analytical methods which are not yet available.

"We must, in every instance, determine the identity and quantity of the migrant. This can be done through the use of laboratory simulated solvents. Techniques are available, as I have indicated, from the Food and Drug Administration, if you don't already know them. Once this is known, we consider the toxicity of the substance. If it is one which can be shown to be safe in any quantity, then it is unlikely that any tolerance for the amount that may be permitted as a migrant to food will be necessary. In such an event, the requirement for analytical procedures for determining quantities of the substance in food may be waived.

"Where the migrant is one for which a tolerance is necessary, there are at least two procedures which, in our opinion, may ease the burden with respect to the need for analytical procedures, and still achieve the basic protection to consumers which is the inherent intent of the Amendment. One would be to establish that the most of any substance that can reasonably be expected to migrate from a packaging material under the most exaggerated conditions of use would be safe. Where meaningful specifications for the parent packaging material can be drawn up, it may then be unnecessary to establish tolerances for the individual migrants since it can be assumed that if the parent material meets rigid specifications, the quantity and identity of the migrants should be reasonably constant. This would, of course, require publication of the specifications of the parent material as part of the regulation which would then simply list the food additive migrants and state that any quantity that migrates from a packaging material meeting the specifications spelled out in the regulation have been found to be safe. Because of the fact that specifications publication is involved here, such action would be only where the procedure is practicable, and with the knowledge and consent of the petitioner. Perhaps you know that we have already filed one petition which follows this procedure.

"Another reasonable approach in dealing with substances that are indirect food additives in quantities too small to measure may be through the establishment of a tolerance of zero using an analytical method of sensitivity specified in the authorizing regulation. This might be acceptable where a practicable method can be developed for detecting in food a quantity of the additive known to be within safe limits. Obviously, we could not use this approach on substances that would fall within the 'cancer clause' of the Food Additives Amendment. Here the zero tolerance would be absolute.

"There may be still other approaches to this problem. If such occur to you, we shall be very happy to discuss them with you. We are willing to adopt any procedures that will simplify the problems facing industry, provided, of course, that at the same time, they permit both Government and industry to fully discharge their responsibilities under the Food Additives Amendment."

Presented at the meeting of the Chicago Section of TAPPI, held in Chicago, Ill., Dec. 1, 1959.

January

The general topic for the January 5 meeting of the Chicago Section of TAPPI meeting was "Knowing Adhesives Means Improved Production." There were three speakers with Paul Gronendyke as moderator.

The first speaker was Eric Heinrichs of the H. B. Fuller Co. Dr. Heinrichs reviewed the basic principles of adhesion and covered the technical aspects of the various adhesives used in the paper industry today.

Charles Murphy of Morningstar-Paisley, Inc., was the second speaker. He spoke on the topic of "Adhesive Problem Analysis." The importance of detailed information was stressed, for it is basic to have all information before making recommendations to solve any type of problem. Cost analysis including labor and down time of an operation sometimes indicates that a better, more expensive adhesive solves a problem and reduces overall cost.

John Coffey of National Starch and Chemicals Corp. spoke on the subject of "Better Adhesive Handling." Mr. Coffey pointed out that proper handling can save money. Drum and bulk shipments were discussed. An ideal glue room was outlined, and methods of distribution were reviewed.

M. H. Meyer

Modern Adhesives: Their Properties and Benefits

E. A. Heinrichs

The American packaging industry is so closely connected with product promotion and advertising that changes are taking place frequently in package design, papermaking, paper coating, and in many areas of the paper converting industry to create more attractive packages and to sell more merchandise. The adhesive industry has tried to help to make this progress possible by developing modern adhesives.

A modern adhesive can be defined as an adhesive that bonds two materials at the required speed and without giving trouble on the machine and that makes a final bond which stands up to the customer's specifications regarding bond strength, color, odor, nontoxicity, water, heat, and migration resistance and what other requirements have to be met.

The first thing an adhesive has to do is to wet the surfaces it has to bond. Without wetting, there can be no adhesion, because the adhesive solids are not in close enough contact with the surfaces to let the forces of attraction do their work. Then it has to have, or to develop, tack. Without tack, there would be difficulties to hold the materials together in close contact until the adhesive has had time to set and to make a bond. Good compression helps but cannot completely replace this.

E. A. Heinrichs, H. B. Fuller Co., Chicago, Ill.

Finally a film has to be formed by the adhesive. Without a more or less continuous film, the strength of the final bond would in many cases be too low.

We'll come back to the mechanics of making a bond when discussing the different classes of adhesives.

Starch and dextrine adhesives still represent the largest tonnage used in paper converting. Starch adhesives are used for corrugating, for laminating paper and paper board and for bag making.

For laminating solid fiber board from three, four, and five plys of paper board and liners, starch pastes and starch-dextrine glues are now being replaced to a great extent by resin starch compounds. Both are usually supplied dry and cooked to a paste by the customer.

There is a great variety of dextrines available for making glue and no matter how complete a line of dextrine glues an adhesive maker has, he still has to do development work in dextrine glues.

Dextrine glues are mainly of two kinds. One kind is usually very high in solids and does not contain any alkali. This type is used, for instance, in bottle labeling and for making envelopes.

The other kind contains borax and other alkalies and finds its use in case sealing, carton gluing, tube winding, and hundreds of other applications. Borax is added to dextrine solutions because it gives the glue a high tack and it has fast setting properties.

The near future may see changes in some of these dextrine adhesives. Borax is not considered nontoxic and it's quite likely that some of the glues that are being used for food packaging will have to be changed.

Where the customer can simply switch to a resin emulsion glue, there may not be much of a problem. Changing to an unborated dextrine will present difficulties.

In the last year or two, there has been one important development in dextrine adhesives and that is a new method to apply a dextrine front seal adhesive on envelopes. This dextrine adhesive is not a solution of dextrine in water but a suspension of dextrine in solvents. Solvents do not swell the cellulose fiber and therefore do not distort it on drying. This results in a lay flat glue line which has its advantages.

No such exciting news can be reported from the field of protein adhesives; animal glue, casein, and vegetable protein. In the paper converting industry, they will keep their place in set up box making, tightwrapping, labelling of boxes and bottles and, of course, for gummed tape, and book binding. But it can be predicted that animal glue will lose a lot of ground as soon as more machines will be designed to work with hot melts.

Animal glue sticks two surfaces together, not by losing water into the paper, but by gelling when the hot animal glue solution cools down on the cool paper.

When an animal glue solution cools down, the water of the solution has to be immobilized by a colloidal lattice work of interlocking protein chains. This jelling doesn't take much time but it is much slower than the setting of a hot melt which is all solids.

We don't have to elaborate on adhesives made from sodium silicate or from asphalt. Both raw materials are used for adhesives in the corrugating and laminating industry but their use is specialized and somewhat outside of the scope of the adhesive industry as it is represented on this panel.

A more promising field for this discussion is adhesives made from synthetic resins. There are two kinds of resin adhesives: thermosetting and thermoplastic. Thermosetting resin adhesives are not used much in the paper converting industry and we can limit ourselves to the thermoplastic resins.

Polyvinyl acetate is still by far the most useful thermoplastic resin for our purposes. And it is in the form of emulsions that most of the polyvinylacetate is used in industrial adhesives.

Polyvinyl acetate emulsion used to be just what that name says—a polymerized vinyl acetate emulsion in water. This is no longer accurate. The term polyvinyl acetate emulsion is now also used for copolymer emulsions. Copolymers contain other resins besides polyvinylacetate and are made by simultaneous polymerization of two or more monomers. Much work has been done in recent years to develop interesting copolymer emulsions.

Up to a few years ago, the adhesive chemist used plasticizers, tackifiers, and sometimes solvents when he wanted a polyvinyl acetate emulsion to bond a difficult surface like cellophane, acetate, polystyrene, lacquered, and coated paper. We still do that but there is a pronounced trend to use internally plasticized emulsions where specific adhesion, water resistance, and other properties are needed.

Some of these copolymer emulsions have one disadvantage. They probably will not be approved by the FDA for food packaging adhesives. Fortunately, polyvinyl acetate homopolymer emulsions can be made so that they have an excellent chance of getting an FDA approval and there are many resins, plasticizers, and other additives on the approved list. A new list is expected soon which should contain many more raw materials with which to work.

The adhesive manufacturers association has retained the services of an independent laboratory to help getting approvals from the FDA. This will certainly take considerable time and, as of this day, I am not aware of a single industrial adhesive that has an approval by the FDA in writing.

Polyvinyl acetate emulsion adhesives have so many advantages in the paper converting field over the older vegetable, animal, and natural resin adhesives, that only a few significant ones can be mentioned here: they can be compounded so that the dry glue line has no odor, taste, or color, and that it has high water resistance. They adhere to more surfaces, their penetration and speed of setting can be better controlled. They are less cohesive than dextrine or animal glue solutions and therefore tend to throw less and almost never cotton. There are less rejects and the glue pot does not need as much watching. Their shelf and pot life are usually excellent; they are easier to defoam, work at room temperature, and often can be applied in such a thin glue line that they are actually more economical than cheaper adhesives.

Resin emulsion adhesives make a wet bond when much of the water has separated from the resin particles by penetrating into a porous surface or by evaporating. Since an emulsion consists of a continuous water phase in which the resin particles are suspended, the water is free to penetrate into paper and the resin concentration between the bonding surfaces goes up fast. Then the resin becomes the continuous phase by coalescing and forming a film which gets very tacky and viscous and gives a wet bond usually good enough to tear fiber.

In contrast, a dextrine glue is a colloidal solution where the water cannot penetrate into the pores of the paper without taking the dextrine along. This solution has a very high viscosity in comparison to water and cannot penetrate as fast into a dense or a coated paper as the water of an emulsion can.

There are many examples of gluing operations where recent development work has produced new adhesives for the paper converter. One of them is in adhesives for folder-gluers for corrugated containers. Some of these machines do their best to prevent the adhesive from doing its work and up to a year or two ago, the type of adhesive generally used was polyvinyl acetate emulsion with vinsol resin. They had good machining and bonding characteristics and excellent water and good heat resistance. But they had a very dark color and that well-known vinsol odor.

Most adhesive manufacturers now have a selection of colorless and odorless emulsion adhesives for each of these machines that have good heat and water resistance, a perfect bond, and don't cost much more than the inexpensive vinsol adhesives.

Another example is foil laminating. The classical adhesives used for laminating aluminum foil to paper for the packaging industry were waxes and rubber latex adhesives. Waxes had water resistance and no odor, but no heat resistance at all. Some rubber latex adhesives had water and heat resistance but a strong odor which excluded them from food packaging. Other latex adhesives had not much of an odor but insufficient water or heat resistance.

New development work with PV acetate emulsions has resulted in resin adhesives that have everything the foil laminator can ask for: nontoxicity, no odor, fiber tear bond, heat, and water resistance.

Rubber latex adhesives are used in the paper converting field predominantly when their specific adhesion cannot be matched by PV acetate emulsions. For instance, when bonding untreated polyethylene to paper board, nylar to paper, and film windows to heavily waxed board. The notoriously poor machining of latex adhesives has been somewhat improved but is still far from satisfactory on fast running machines.

One area where natural rubber latex adhesives have expanded tremendously in the last few years is in self sealing containers. These may be corrugated boxes, cartons, bags, or envelopes. The principle is not new, only its application has been improved.

There are corrugated containers on the market now which are shipped collapsed, are opened in the lettuce fields of California, filled with lettuce, and simply sealed by pressing the latex coated flaps together by hand. The principle of latex self seal is that a coating of natural latex, when dried, does not stick to anything but to the same coating. Both surfaces that have to be sealed are coated by spraying, roller coating, or stencil application, dried and shipped so that no coated surface can touch another coated surface.

Modern rubber latex adhesives of this type have excellent aging characteristics and seal after 9 to 12 months just as well as when they were freshly coated. Their biggest enemy is dust, not oxidation.

One type of adhesive that has been under development for many years and is finding more and more use in certain specialized fields, but has found its way into the paper converting field in only a few applications, is hot melts.

There is no doubt that PV acetate emulsion adhesives and other water based products are approaching the limit of their performance as far as speed of setting is concerned. If the paper converting and packaging industry should ask for much more speed in straight line gluing, cup making, carton sealing, etc., we are quite prepared to come up with hot melts, but first of all, the machine designer will have to build the machines.

There are strong tendencies in this direction in some other fields like magazine binding, but is very likely that carton forming and straight line gluing will be converted to use hot melts sooner or later. Other possibilities are machines on which resin coatings can be reactivated by heat or solvents.

All adhesive manufacturers are trying to limit the number of products by offering standard adhesives first. Even so, many products are tailormade for one or for a few applications only.

This means that your adhesive supplier is more than just a supplier. He tries to be a technical consultant and a trouble shooter besides.

Often when a paper converter has a truckload of carton stock all printed and die cut, he finds that it does not glue properly.

This is the situation where an experienced adhesive supplier has to do some fast work in the lab and on his mixers to keep your production rolling.

Much of this is still being done by trial and error, but the day will come when we can read the molecular structure of a surface to be bonded from one chart, and can select the best possible adhesive for it from another chart. Until that time comes, we know that good service and uniform products will keep us in business even if we complain sometimes that you always want the answer to a problem yesterday.

Presented at the meeting of the Chicago Section of TAPPI, held in Chicago, Ill., Jan. 5, 1960.

Adhesive Problem Analysis

Charles Murphy

By way of introduction to this subject material—it may be of some interest to you to learn of two types of adhesive problems which confront adhesive manufacturers from time to time.

The 1st usually begins like this: "We have a glue problem: please send us a sample of your adhesive."

The 2nd is slightly more complicated and goes something like this: "We have a glue problem, please send us your catalog. . ."

In conveying to you our experience and ideas concerning adhesive problem analysis and how comparative tests of adhesives are conducted, we will project some of these ideas and suggested methods on slides and explain the importance of various points as to how they assist both the adhesive user and supplier in overcoming mutual problem of selecting an industrial adhesive which meets all or most of the foreseen service requirements.

In the general analysis of adhesive problems, there are three essential categories worthy of consideration; the first being the actual operating requirements of an industrial adhesive which is covered in an "Adhesive Operation Data Sheet." The questions asked although they are probably fundamental to most of the audience, are nevertheless, quite important—important in this respect: that the more information your adhesive supplier has, pertinent to your problem, the better equipped he is to make an initial recommendation so as to save you—the user—costly evaluation time and assist you in selecting the best, over-all, economical adhesive for your particular needs.

The questions which are asked should be completed in detail; and if certain of the points which are raised are not of importance, they should be designated as such, for, after all, even a negative response to a particular question, whether or not it appears to be important, is of value to your adhesive supplier.

The second category of our adhesive problem analysis is concerned with the operating performance of the adhesive in which the user seeks modifications or improvements in his present material. Here again, as in our adhesive operation data sheet, there are similar questions under operating conditions, but when we consider the performance section, we go into more detail, since it is assumed at this point the user himself is more acquainted with the specifications concerning the particular situation.

Here again, answers to all of the questions, regardless of how insignificant they may appear, have a useful role in assisting your adhesive supplier to make the best recommendation to you.

The third category in our analysis of adhesive problems concerns itself with a situation which most of us would like to forget, but are confronted with at one time or another by conditions which are frequently not under our control, but nevertheless, do occur. This is in a "Product Complaint Form" which our field servicemen are required to complete in detail so as to assist your adhesive suppliers' laboratory in getting to the root of the trouble. Many small details are taken into consideration, and I cannot stress too strongly the importance of complete information when reporting a situation to assist in properly analyzing these problems.

Charles Murphy, Morningstar-Paisley, Inc., Chicago, Ill.

Table I. Performance/Cost Analysis of a Dextrine Type versus Resin Emulsion Type Carton Sealing Adhesive

At present the packaging section on the No. 2 Jones Line for 50 cc. XXXXX utilizes the services of 8 girls and 1 man.

8 girls @ $1.72 per hr. =	$13.76 per hr.
1 man @ $2.12 per hr. =	2.12 per hr.
Total	$15.88 per hr. or $0.26/min. (labor)

Present glue cost: borated dextrine type
Priced at $52.50/55-gal. drum or 10.50/100 wt. (500 lb./55-gal. drum)
Usage per day: 10 qt. @ $0.24/qt. = $2.40/day (Glue cost) or 0.005/min. (Glue cost) (based on a 445-min. day).

Proposed glue cost: modified polyvinyl acetate
Priced at $115.00/55-gal. drum or 23.00/100 wt. (500 lb./55-gal. drum)
Usage per day: 5 qt. @ $0.52/qt. = $2.60/day (Glue cost) or 0.006/min. (Glue cost) (based on a 445-min. day).

Conclusion:
By going to the new glue, we will eliminate all down time on the line as a result of nonglued cartons. As you can see above, our glue cost per minute for each glue is practically the same ($0.005 versus $0.006). When you consider that for each minute we are down on the line, as a result of glue, we lose $0.26 in labor, the glue cost is negligible. We could further expand the picture by stating that we lost 135 cartons during that 1 min. down time in production.

Table I titled: "Performance/Cost Analysis of a Dextrine Type versus Resin Emulsion Type Carton Sealing Adhesive. . ." is a typical example of how an adhesive supplier can save you money and improve the efficiency of your operation, if he has information such as previously explained to you. The data in this Table were accumulated by a major pharmaceutical manufacturer as a result of their experience to improve packaging costs in a particularly troublesome area. You will note that they had been using a borated dextrine adhesive which they thought was doing a satisfactory job on a "not too difficult to adhere" board stock. In their efforts to improve the situation, adhesive operation data forms and performance reports were completed in detail, which enabled the adhesive supplier to assist them in overcoming the problem.

While statistical data such as these are not always available in many cases upgrading or improving current operations can be accomplished with savings if the adhesive supplier has available to him the data previously discussed.

Presented at the meeting of the Chicago Section of TAPPI, held in Chicago, Ill., Jan. 5, 1960.

Delaware Valley

The Delaware Valley Section of TAPPI held its monthly meeting on Dec. 4, 1959, at the Engineer's Club in Philadelphia. Featured at this meeting was a presentation by D. O. Paulsen outlining the safety program of E. I. du Pont de Nemours and Co.

In the year 1960, the 270th Anniversary of America's first paper mill built in Germantown by Wilhelm Rittenhaus and the 275th Anniversary of the first print shop in the Middle Colonies established by William Bradford. In line with this tradition, Philadelphia continues to be an important center of both industries and makes a most appropriate location for a major Graphic Arts Conference.

The Delaware Valley Section of TAPPI is planning a bigger and better Third Annual Philadelphia Conference of the Graphic Arts Industry to be held at the Benjamin Franklin Hotel in Philadelphia on Saturday, March 26, 1960, from 8 a.m. to 5 p.m.

Please reserve this date and attend this conference to promote greater mutual understanding and cooperation between papermakers and graphic arts people.

Preconference registration fee is at the bargain price of $7.50 versus $10 at the Conference. Send registration fee to Mr. H. L. Smaine, P. H. Glatfelter Co., Spring Grove, Pa.

T. P. Czepiel, *Secretary*

Success with Safety

D. O. Paulsen

We in the du Pont Co. have come to believe in safety as a way of life. This concept is not new, but, rather goes back to the days when our company was first founded over 150 years ago. The very roots of this safety philosophy lie in those early days, even before original construction began on gun powder mills on the banks of the Brandywine River in Delaware. To illustrate the roots of this safety philosophy, we have a brief film clip from the motion picture, "The du Pont Story." The opening scene portrays an interview between Thomas Jefferson, President of the United States, and Eleuthere Irenee du Pont, the founder of our company. The year is 1801. This was the beginning, but the present concept was not completely formed until the passing of Workmen's Compensation Laws in 1911 and the formation of the National Safety Council in 1913.

Here is a summary of du Pont's safety performance during 1958:

Injuries	58
Fatalities	2
Frequency	0.32
Total hours	178,000,000

Here are some additional figures—these represent the Du Pont Co.'s safety performance in the year, 1916:

Injuries	3238
Fatalities	115
Frequency	31.2
Total hours	104,000,000

By 1927 we had reduced the frequency of time losing injuries to 10.3. If we had not been successful in reducing the rate subsequently to the current figure of 0.32, we would have had in the interim period over an additional 40,000 injuries.

Accidents are expensive. It is estimated by the National Safety Council that the current cost of industrial accidents averages about $55 per employee. As an example, a plant with 10,000 employees can anticipate an average annual accident cost of $550,000 per year. Accidents are not only expensive in dollars and cents but in time lost from work by valuable and experienced employees. The time lost from work by employees of industry in the United States annually is about equivalent to removing from our national working force 1,200,000 men and women—or in other words, removing from production all the plants of the Ford Motor Co., The United States Steel Corp., General Motors, and the du Pont Co. It is estimated that all types of accidents cost our economy in excess of 11 billion dollars per year—this approximates about one-fourth of our current annual budget for national defense. We can readily see that there is a need for safety and that safety literally pays.

SAFETY PROGRAM

How do we arrive at success with safety? What is the answer? We feel that the keystone of a successful safety program is the mass motivation of all employees to make safety a way of life. And, as we might expect, safety begins here:

Top Management. The basic thinking or philosophy on the prevention of personal injuries as stated by W. S. Carpenter, Jr., chairman of the company's Board of Directors, is:

"We, in the du Pont Company, long ago concluded that the safety of employees is of the greatest interest to management, ranking in importance with production, quality of product, and costs. We have found that maintenance of safe operating

D. O. Paulsen, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

procedures in our plants is of benefit far beyond any resulting dollar savings, the human values involved being of greater importance both to the employer and the community. Also the acceptance and practices of fundamental safety principles by management and men, with the reduction of personal injuries to a minimum, injects an element of team play which does much to foster a spirit of friendly cooperation throughout our company."

Maintain a Safety Organization. What contributes to a successful safety program? We must maintain a safety organization to implement the program; we have a Safety and Fire Protection Division in Wilmington that acts as safety advisor to the operating plants, research groups, and sales groups. But the responsibility rests with each individual to work safely as an integral part of production. The safe worker or individual is:

One who believes all personal injuries can be prevented
One who is alert
One who accepts responsibility
One who safeguards machinery
One who has job knowledge
One who obeys safety rules
One who has good safety attitude
One who uses safety equipment
One who learns from training

To get the safety message across to the individual, our plants have found that the Safety Committee organization is very effective. The Central Safety Committee is comprised of the plant manager as chairman, the plant safety engineer, the plant physician, and the respective department heads. The committee meets monthly, and they are charged with the following responsibilities:

A. To guide, originate, and coordinate the plant safety activities.
B. To provide a distribution medium for all safety policies.
C. To supervise general plant safety educational works.
D. To perform final investigation of personal injuries or plant accidents and to find the means for eliminating the causes.
E. To arrange for plant safety inspections and elimination of hazards.
F. To establish plant safety rules and standards.
G. To arrange tests, studies, engineered safety standards, etc.
H. To promote type maintenance and use of safety devices.
I. To initiate safety publicity, contests, campaigns, etc.

We mentioned the safety engineer as a member of the Central Safety Committee. What are his specific functions? He attends the foreman and department safety committee meeting, where decisions arrived at by the Central Safety Committee reach every plant employee. He assists in the development of safety publicity, by use of posters, signs, newspaper articles, contests, or special programs. He makes recommendations to plant management for subcommittee appointments. Some of the examples of this work would be the creation of a committee to study use and need for release valves on pressure vessels or a committee to institute and apply methods of safely eliminating sources of combustion on the chemical plant. The safety engineer also makes monthly reviews of every operating department's safety performance and reports to top management with recommendations of corrective action for the future. He reviews all new installations and procedures and makes recommendations on all safety aspects. Money cannot be released for the project until the safety engineer has approved it.

Elimination of Physical Hazards. A second essential for a successful safety program is the elimination of physical hazards. The control of physical hazards is not only necessary to protect people from inadvertently coming in contact with moving equipment and pinch points and to act as physical barriers to contact with dangerous materials, but these safety guards point out to the employee that management takes safety seriously. Adequate mechanical guarding is an important aspect of a successful program. Not only will injuries be greater without it, but it will be far more difficult to create the proper safety attitude among the individuals working with improperly guarded and/or maintained pieces of equipment.

Control of Work Habits and Practices. A third point to mention concerning a successful safety program is the control of work habits and practices. It is necessary to have the individual wear protective equipment—this is, safety shoes, protective glasses, gloves, hard hats, etc. An example of this would be the eye protection program.

Before discussing this program, I would like to define two terms that are used by our company—a major injury and submajor injury. A major injury is one whereby the employee suffers any degree of permanent disability which interferes with normal physiological functions or causes time loss. Time loss is the inability of the employee to return to an established job on the day following the injury or a subsequent day, whether scheduled or not. A submajor injury is the case which interferes with the ability of the employee to perform his regular duties because of the severity of the injury or the duration and frequency of treatment.

As mentioned earlier, an example of the use of protective equipment is the eye protection program. In the period 1940 to 1945 at the Chambers Works, it was apparent that we had far too many eye injuries from corrosive liquids and from impact. In 1945 we had 26 major and submajor eye injuries. After analyzing the large number of minor and serious eye injuries, talking to large numbers of workmen and visiting other plants, these three major conclusions were reached:

1. Specified eye protection was not being worn because it was not properly fitted or properly maintained. (Glasses were improperly fitted and/or maintained.)
2. Because eye protection was specified to be worn on an individual basis, there was too much leeway for individual judgment. (Protection not specified.)
3. Not enough justification for the need for eye protection had been given workmen. (Not enough justification.)

After the committee studied this report, they came up with the following steps to reduce the eye injury rate:

1. An optical technician was employed to fit spectacles and goggles.
2. A minimum of side shield spectacles was recommended for all persons in operating buildings, shops, or in the vicinity of outside operation or mechanical work.
3. An intensive education program was adopted, stressing the value of eyesight and showing examples of eyesight saved by spectacles and goggles.
4. Rather than make the wearing of side shield spectacles mandatory throughout the plant at once, we allowed each area to adopt or not adopt the rule as they saw fit. One by one we got the majority of the workmen in each area to agree to the program, until three years later we achieved complete uniformity. Finally, in October, 1949, we rewrote this into a plant-wide rule requiring the minimum of side shield spectacles in all operating buildings and shops and in the vicinity of outside operating or mechanical work. Later, Chambers Works laboratories were included. When employees performed specific jobs where eye hazards were pronounced, they were required to substitute chemical goggles, nono-goggles, face shields, or other devices that were specified.

We feel the program of reducing eye injuries was a success. Use of protective equipment—such as hard hats, safety shoes, safety glasses, and the like—can reduce the accident frequency rate.

Proper Management Attitude. You will recall that I quoted a statement from W. C. Carpenter, Jr., stating the basic thinking in du Pont. This points out the fourth essential of a successful safety program—proper management attitude. When men not only believe in safety but insist upon it; when safety is demanded at the top and is considered important to a man's performance record, then there is nothing to stop it from being emphasized down the ranks to the newest wage roll employee.

An example of this is shown by the actions of one of our plant managers in 1928 at a plant that he had just taken over. The safety record was very poor, so he installed guards and

efforts, the workmen could not be convinced that safety came before everything else. The plant manager arrived at the conclusion that some drastic action was necessary. One day, when the second injury within a week occurred, this drastic action was taken. The manager ordered the plant shutdown. Over 1000 workmen were sent home and the supervisors and foreman were told that accidents must stop. They were requested to review their areas and take what steps were necessary to operate the areas safely. When all were completed, they were to return to the plant manager and report. After about three days, all foremen had reported to the plant manager that their areas were safe in which to work. At that time the plant was again started up and operated for almost a year without a lost-time accident. Proper management attitude.

Another example is a little more up-to-date and goes back only about two years to the time that one of our plant managers was attending a regional safety conference. Our man was approached by a safety engineer from a plant operated by another company, and asked to disclose the secret of du Pont's success with safety. Our man asked the other fellow what their safety performance had been—and then what their plant manager thought about it. The safety man said in effect, "Oh, he doesn't seem to be concerned!" Our man maintains right there is the secret—if there is one—of du Pont's success with safety. Proper management attitude—without it we feel our best efforts would produce only mediocre results.

What remains? It is now necessary to convince the individual to protect himself against himself. The last mile is the longest and hardest and most difficult to cover, because people are basically gamblers. You play poker, perhaps not realizing that the odds against drawing a royal flush in a five-card deal are 650,000 to 1. Yet, people continue to gamble with safety, figuring they got away with an unsafe practice once, they can do it again. It is essential that the worker be motivated to live safely, work safely, think safely, in other words each individual must make safety a way of life.

It now becomes essential to influence a man's thinking—psychomotive safety. We must get through to his mind and make certain our messages concerning safety are being received and recorded, not momentarily but for life. One way is through statistics of safety. For some reason people keep in mind statistics of safety.

This is just one approach. We also have available an organized program of talks that are given at the various meetings. Some of these that we use are titled:

1. Available Statistics
2. Safety Gremlins
3. What Makes People Tick?
4. The Whole Man
5. Your Eyes and Your Life
6. The Hard Hat Won't Save You
7. A Cable Will Hold, But How Much?
8. Death Takes the Wheel
9. Safety and Religion
10. The Home Handyman

Additional promotions may be used to get through to the individual—that is, dramatic demonstrations, movies, pictures, and posters illustrating accidents about to happen, on-the-job safety analysis, etc. We have available a 5-hr. training program on the method of approaching psychomotive safety which may be presented to groups of 10 to 12 people. The first hour is devoted to philosophy and psychology, the second hour to methods, and the third, fourth, and fifth hours to practices, criticisms, and explanations.

Another approach is the Summer Safety Show conducted in our Chambers Works plant, which was an attempt to carry-over the "on-the-job" safety thinking to "off-the-job" safety thinking. Last year the National Safety Council reported a frequency ratio of 1:4 "on-the-job" to "off-the-job" injuries. In other words, you are four times safer on the job than at home. Our program was organized to have as many people as possible participate and to have every one of the plant personnel review at least two of the plant shows. By actual count, 15,500 people viewed the area demonstrations, of which there were 28. These shows pointed out how plant safety could apply at home. Movies were made of each area display, and these are in free circulation around the plant, to be used as safety meeting topics. Was the program a success? Judging from "off-the-job" accident rates which we attempted to lower by the Summer Safety Show—it was. We have a short 10-min. film taken in one of our areas showing the type of demonstration setup and the tie-in between safety "on-the-job."

These are the mechanics and what we feel can be done. Invariably in any discussion of safety, cost and possible cost reductions as a result of a low-injury rate are discussed. We are convinced that smooth operation without unusual incidents is reflected in lower costs, or in a time of rapidly rising costs help materially to "hold the line" on costs.

Costs of accidents may be broken down into direct and indirect costs. Direct costs are obvious—outside medical expense, compensation both in lump sum for permanent disability and in maintenance of wages while the employee is totally unable to work. These are the direct costs.

Indirect costs usually run four times the direct costs. Indirect costs cover many things. A few are:

1. Lost time of the injured person on the day of the injury.
2. Fellow workers stopped to sympathize.
3. Personnel to assist the injured employee.
4. Lost production due to diverted interest of employees.
5. Stoppage of the processes in charge of the injured.
6. Off-quality product due to emotional upset of workers.

Many other things may be listed as indirect costs due to an accident.

A safe worker and a successful safety program go hand in hand. What is necessary to accomplish this? A good safety program:

1. Effective communication
2. Over-all participation
3. Incentive
4. Safety suggestion system
5. Safety rules
6. Job procedures
7. Periodic inspections
8. Safety promotion
9. Special training
10. Investigation of accidents
11. Proper attitude
12. Periodic review

We have mentioned the role of top management and the need to emphasize this down through the ranks to the newest wage roll employee. We all know the human element is always the weakest link in the chain of events that leads to accidents. The plant that is successful in accident prevention has more than a set of safety rules. They have more than aggressive supervision—they have confidence and trust in each other—quality of leadership which generates an atmosphere in which people can work together safely, intelligently, harmoniously, and enthusiastically.

Accident prevention with du Pont is not a fringe issue. It is an integral part of each management responsibility.

Presented at the meeting of the Delaware Valley Section of TAPPI, held in Philadelphia, Pa., Dec. 4, 1959.

Golden Gate

Some Thoughts on the Economics of the Paper Industry

Howard Baumgarten

MEMBERS of TAPPI by and large work for what the Department of Commerce calls the paper and allied products established all routine safety procedures. With all the best

HOWARD BAUMGARTEN, Gardner Board & Carton Co., Middletown, Ohio.

industry. This isn't the half of it really. Not included in this classification are the lumber and wood products industry with whom paper shares a basic raw material. Nor is printing, publishing, and newspapers included with the allied products portion of our industry. These, too, convert or process paper into more usable forms.

In outline, our industry as defined looks like this. Starting with wood, or its first cousin once removed, wastepaper, there are several steps of processing to the end uses of (1) packaging, (2) cultural uses, (3) household use, (4) industrial use, and (5) building. There are any number of ramifications due to the alternate paths that the product can go or the competition met by paper along the line. But my purpose is to simplify further. The paper part of the industry by which we mean pulp, paper, and paperboard manufacture has an underlying basic economic character. And the allied products part of the industry by which we mean bag manufacture, off machine coating, box manufacture, folding, corrugated and setup, envelope manufacture, cans, tubes and drums, and molded pulp products, has a quite different basic economic character.

The paper machine is the epitome of the paper part of the industry. It is a large, expensive, piece of capital goods and this is typical of the industry. It costs a lot of money so that entry into the club is limited to those who can afford the initiation fee. In order to make out, with a profit, the paper machine must operate as close to 7 days per week, 24 hr. a day, as is possible.

On the other hand the converting part of the industry is a relatively smaller capital commitment. The range of capital needed to enter can be small or large. It is divisible. Converting plants are more oriented to the marketing aspects of business; closer to the customer. Turnover of capital is faster. The major cost is the raw material which on a rule of thumb basis may be about 50% of the total cost. The size of the plant is smaller. You will find more people involved in the converting process. Altogether the character and competition in the allied products sector is different from the character and competition in the primary paper sector.

Characterizing the paper machine again, that monstrosity sucks up hugh volumes of liquid and removes a small percentage of solids in a sheet form. To do this takes thousands of tons of metal, a square block-or-so of space, and several different methods to accomplish the mission. It's a dinosaur. As long as the basic process remains, the paper industry will use a large amount of capital and the major emphasis will be on running it as continuously as possible.

The paper sector of the industry has total assets of $5.9 billion dollars. Divided among some 1100 mills this means $5\frac{1}{2}$ million of assets per mill. Much of the original book value has been depreciated. And the new mills cost several times that figure. The replacement cost today would be tremendously higher. On these assets the industry gets $1 of sales for $1 of assets. If the assets were valued at today's prices it would take $2 or $3 to produce a $1 of sales. The net return after taxes has ranged from 12% on sales in 1947 steadily on down to 6% in 1957 and somewhat less in 1958. 1959 will be a modestly better year for profits.

Another way of exploring what the basic economics of the industry mean is by constructing a breakeven chart. The largest items of fixed cost that do not vary with business volume are depreciation, taxes and insurance, salaries of management, and maintenance. Fixed costs total approximately $1\frac{1}{2}$ billion per year. As in Russia where equality reigns, some people are more equal than others, so in the breakeven analysis, some fixed costs are more fixed than others. Over a period of time there is a flexibility in how fixed some costs are. In a series of good years fixed costs expand. In a recession year, fixed costs get chopped. Management can and does reduce or increase fixed cost commitments in the intermediate or longer runs.

The variable costs start from on top of the fixed and move upward directly and proportionally with volume. Add a sales or revenue curve and the chart is complete. Where the sales curve and the total cost line cross is the breakeven point. To the left of this point losses occur; to the right are pretax profits. For the primary paper industry the break-even point appears to be between 60 and 70% of capacity.

A second way of estimating the breakeven point and a cross-check is by correlating the profit margins and per cent use of capacity over a period of years. Along the one axis is the per cent of capacity operated by the industry and along the other axis is charted net return before taxes. A line describes the relationship. Again the breakeven point would appear to be between 60 and 70%. This technique is weak because it is based in part on old data. But the most recent points are falling below the regression line and this infers a higher breakeven than the older relationship.

Contrast this to some steel companies that operated at 50% of capacity during some quarters last year and made good net profits. Or look at the automobile industry that operated at 43% of capacity at certain periods last year and about broke even. In 1960 autos may be operating at 65% and will, at that level, return handsome profits to all five operating companies.

Breakeven varies greatly within an industry. In the automobile industry, Chrysler and Ford on occasion have lost money while General Motors at the same time was in the black. I mention the auto companies because similar information is not readily and publicly available in the paper industry. However, you all recognize the truth that there are variations within the paper industry.

The allied products sector of our industry is a contrast to this. The total assets are less than half of the primary paper sector. The assets have grown from $1.2 billion in 1947 to $2\frac{1}{2}$ billion in 1957. But these assets generate almost $2 in sales for $1 in assets as contrast to the 1:1 ratio in the paper sector. The return on sales is consistently less as would be expected with the faster turnover. It is currently in the 2 to 3% range, after taxes. It was as high as 7.8% in 1947 but has dropped steadily. It is low now. With such a low average, it would be likely that some companies are even operating in the red.

Within the allied products sector the diversity in size of plant, the variation in type of operation, the variation in the degree of specialization of personnel is much greater. In the box part of the business, which I know best, there are converters with $\frac{1}{2}$ million (each) gravure printing presses lined up in a plant; and then there are converters with two $10,000 flatbed letter presses—garage installed. There are electronic eye register mechanisms in one case and rule-of-thumb make-ready techniques in the next plant. The contrast is great. Some are in the business for better or worse year in and out; some get into a few accounts on a seasonal basis then get out or go bankrupt. The ease of entering this business necessarily limits the return on investment. There are some 3800 plants listed and I doubt that this is all. Even with this number this means average assets of an estimated $650,000 per plant. Contrast this to $5\frac{1}{2}$ million/plant or nine times as much in the paper sector. These plants are located, not near the timber but where the customers are and they do not ship the product great distances.

I have not constructed a breakeven chart for the allied products sector. Any attempt would be based on such tenuous assumptions as to plant capacity, personnel, and other costs as to be highly questionable. One can generalize that by and large the level of fixed costs are lower; the spread between total cost and total sales is narrower; and that the breakeven point is sufficiently high that large profits are not in the picture, even at 100% capacity.

As the merger trend has progressed, these two parts of the industry have been brought closer together. The mergers have in part been motivated by the economies of more closely integrated operations; quality control and better understanding of ultimate end use needs; elimination of selling costs have played a part in making mergers economically sound. It may be that some mergers have been promoted on the bases of running paper machines at higher rates of capacity.

Table I. Total Assets in 1957
(In billions of dollars)

	Paper and allied industry	*Pulp, paper, and board*	*Allied products*
1957	$8.41	$5.91	$2.50

There is a clear need to delineate the separate and diverse characters of the two major parts of our industry. One management technique is to separate the various parts of an integrated company into operating divisions with each profit center making its purchases from other divisions at market price. Another technique is to borrow the strong points of the other part of the industry: so the converters become more manufacturing and efficiency conscious and the primary paper sector becomes more marketing conscious. However sound these and other methods may be there remain other problems in the industry. One major one is some degree of overcapacity.

Capacity is a tough concept to define, measure, and understand. The trade associations in the primary part of the industry have made excellent capacity surveys for some time. A calculation of the operating to capacity ratio is available currently in the paper and paperboard fields. It has only been recently that these surveys have been extended to a 3-year forward look at planned capacity increases.

However, in the converting industry capacity studies are almost nonexistent. *Paperboard Packaging* magazine has measured capacity in the folding carton industry by using cutters listed in their Official Container Directory. On the base of 1947–49, capacity appears to have increased over 50% while sales tonnage has gone up 25%. In folding cartons industry nothing has been done by the industry association and the problem in doing something is quite difficult conceptually. I do not know of a good estimate of capacity and production in the corrugated box industry.

A few minutes ago growth was mentioned as one of the factors that will help the industry and its profitability. The growth rate of the paper industry will have an important bearing on the capacity utilization problem.

The program committee asked me to make some industry-to-industry comparisons. In fact today everyone seems stock market and/or growth industry conscious. As a basis for comments I am taking figures developed by the Department of Commerce. Some 300 industry groups or products are included in two periods—1929–55 and 1948–57. There are several limitations to any growth rate analysis.

1. Not all products are included although this list is comprehensive.
2. New products get neglected for lack of data over a long enough period of years.
3. Some industry data are understated because the industry is classified under other headings and doesn't report.
4. The selection of the base year can affect the calculated rate.
5. The level of the base year affects the growth rate.

This tabulation covers a wide range of products and services and it gives general comparisons.

In the postwar decade there are many products growing at very high rates. For example among others

growing 40% and more are: transistors, antibiotics, polyethylene, vitamins.
growing 30 to 40% per year are: air ton-miles flown, tape recorders.
growing 20 to 30% per year are: effervescent wines, polyvinyl resins.

The highest growth rate in the paper and allied industry is paper milk containers at 15 to 20% per year. Also in the 15 to 20% range are two items that go together—distilled spirits, withdrawals, and ice making machines. Fiber drums are growing 10 to 15%, shipping containers and sanitary tissue 6 to 7½%. Total paper and board is 4% per year. There are as many, if not more, products growing at slower rates than paper and board. Do not mistake my mentioning the glamorous high-growth products as a criticism of the paper industry which has a better than average growth rate and is a much older industry than these others. But I did want to give you some facts and I have the complete Tables here for you to look at.

Table II. Sales

	Paper and allied industry		*Pulp, paper, and board*		*Allied products*	
	Billions	*% Earnings*	*Billions*	*% Earnings*	*Billions*	*% Earnings*
1947	$5.53	10.3	$3.24	12.1	$2.29	7.8
1948	5.85	8.3	3.45	10.3	2.40	5.5
1949	4.86	7.5	3.06	8.1	1.80	6.4
1950	6.66	8.4	3.91	9.7	2.75	6.5
1951	8.20	6.4	4.75	7.6	3.45	4.8
1952	7.65	5.4	4.21	6.5	3.44	4.0
1953	8.16	5.1	4.61	6.5	3.55	3.3
1954	8.28	5.2	4.87	6.4	3.41	3.5
1955	9.54	5.9	5.48	7.6	4.06	3.6
1956	10.69	6.1	6.14	7.7	4.55	2.6
1957	10.42	5.0	5.99	6.3	4.33	3.3
1958	10.66					
1959	11–12 Est.					

Table III. Net Income of Leading Corporations, 1957 & 1958

	Return on net assets, % 1957	1958
1852 Manufacturing companies	12.9	9.8
71 Paper and allied products	10.6	9.1
72 Chemical companies	14.0	11.1
27 Drug	23.7	21.9
121 Oil products & refining	13.7	10.2
112 Electrical equipment (radio & TV)	13.9	12.2
26 Office equipment	18.0	14.1
76 Instrument, photo goods	15.1	12.2

Source: First National City Bank Bulletin, April, 1959.

Related to, but more important, in my opionin, than growth is profits. Again at the suggestion of the program committee, here are the profit rates of a sample of large corporations in the glamour-growth industries. In terms of return on net assets, none of these industries were under the paper and allied products industry. The overall average of net income to net assets for all the 1850 manufacturing companies in the First National City Banks' tabulation was almost 13% in 1957 and dropped to under 10% in 1958. The paper companies were below average at 10½% in 1957 and was 9% in 1958. This is a pretty hot list of competitive industries. Even the ailing oil group made over 10% in 1958. There are many industries well below paper in return.

I would sum up our growth and profits situation with an eye to both its favorable and unfavorable aspects and prospects. Both rates—growth and profit—are respectable but not exciting. To give this perspective, so long as we continue to develop new uses for our products our profits and growth will be respectable and we hope more exciting.

Presented at the meeting of the Golden Gate District of TAPPI, held in San Francisco, Calif., Dec. 1, 1959.

New England (Eastern District)

The Eastern District of the New England Section of TAPPI held their annual meeting on January 11 at Armand's Beacon Terrace in Framingham, Mass. Chairman Roger Wiewel opened the meeting at 8:30 p.m. with 104 present and called for a report from the chairman of the Nominating Committee, charter member and first chairman of this district, Norman Bearse. The latter thanked the members of this committee, Ray Kilty, C. W. Stillwell, and Charles Horch and submitted the following slate:

Chairman, John W. Wendell, Jr., Tilestone & Hollingsworth Co., Hyde Park 36, Mass.
Treasurer, Philip L. Slayton, Monsanto Chemical Co., Everett Station, Boston, Mass.
Vice-Chairman, Albert C. Lamoureux, Dennison Mfg. Co., Framingham, Mass.
Secretary, David W. Lovering, Arthur D. Little, Inc., Cambridge, Mass.

EXECUTIVE COMMITTEE

Thomas Allan, Virginia Smelting Co., 5 Pilgrim Way, East Walpole, Mass.
Charles Horch, Mead Corp., Leominster, Mass.
John Francevicz, Oxford Paper Co., Lawrence, Mass.
Frank R. Fitz, Mead Corp., Leominster, Mass.
Edmond C. Kelley, Louis DeJonge Co., Fitchburg, Mass.
Prof. John Lewis, Lowell Technological Inst., Lowell, Mass.
Thomas J. Sargent, Nashua Corp., Nashua, N. H.

No further nominations were made and the above were unanimously elected for the coming year. The Nominating Committee recommended that consideration be given at some time during the coming year to a change from electing all the members of the Executive Committee each year to that of changing only two each year.

Treasurer, Phil Slayton, submitted his report showing a balance on hand of $1173.25 or an increase of slightly over $600 this past year.

Chairman Wiewel suggested that all who plan to attend the joint meeting with the N.E. Section on June 3, 4, and 5 make reservations with the Chatham Bars Inn at Chatham, Mass., at once as the main hotel was already almost entirely booked and the choice of rooms would soon be limited to the Annex and adjacent cottages.

The next meeting of the Eastern District will be on March 7, the first Monday instead of the usual second Monday of the month.

A. E. Moyer of Synco Resins, Inc., of Bethel, Conn., delivered a talk on Chemical Modifications of Paper, Particularly Beater Additions of Phenolic Resins.

An active question-and-answer period followed during which Mr. Moyer elaborated as to methods and conditions of use and comparison of results obtained with Phenolic Resin Beater Additions as compared to results obtained with alternate treatments.

Roger Wiewel then turned over the gavel to incoming chairman, John Wendell, who pledged his efforts at continuing the successful leadership enjoyed so far by the Eastern District.

Charles Horch and Prof. John Lewis joined in expressing appreciation for the outstanding service of Roger Wiewel. Prof. Lewis announced that the next meeting of the New England Section would be held at Storrowtown in West Springfield on April 8 at 5 p.m. in the Barn. Prof. Alfred K. Nissan of Rensselaer Polytechnic Institute will speak on the subject "Some Aspects of Hydrogen Bonding.

A. C. LAMOUREUX, *Secretary*

Phenolic Resins in Beater or Wet End Additions

A. E. Moyer

ABOUT ten years ago some specially prepared condensation polymers of phenol and formaldehyde were successfully introduced for the manufacture of filter media by the process of beater addition (*1*). Beater addition can be regarded in the generic sense since there are several points at the wet end which are ideal for such additions outside of the beater itself.

In the ensuing period phenolic beater addition resins of both liquid and solid types have found other advantageous applications such as in plywood and lumber overlays, fiberboards, printing plates, friction materials, gasketting, automotive boards, luggage boards, honeycombs, and others.

Prior to this period beginning shortly after World War II the use of powdered phenolic resins in slushes for pulp molding had been fairly well known.

However, the content of this paper will emphasize the more recently developed liquid-type resins.

These resins are prepared in a fairly wide range of molecular weights by adjustment of reaction constituents, catalyst concentrations, and reflux times. The end use as well as mill application conditions dictates which combination is best employed, and this must be carefully controlled by the manufacturer.

Basically, the reactants are phenol and formaldehyde at an approximate mol ratio of 1:2 in the presence of an alkaline catalyst (*2*). The reaction is carried out under reflux at atmospheric pressure for a predetermined period or until specification conditions have been met. The condensation polymer is thus formed by methylene bridging at three reactive points which are *ortho* and *para* to the phenol hydroxyl group. The growth of the polymer is linear and, of course, with the three dimensional properties which ultimately result in crosslinking and thermosetting after continued heating and/or pressure and heating.

When these resins are added to beaten or broken up stock under the usual paper mill conditions their water tolerance is always exceeded. This results in a reversion of appearance of the resin from a clear reddish amber liquid to a milky white state of quite high opacity. Actually, this is self-emulsification to an extremely fine particle size as determined by examination of the resinated fibers using an Ultropak microscope with fluorescent light (*3*). The resin appears only as a faint haze which indicates an excellent dispersion and very small particle size.

The electrokinetic mechanics of attaching the resinous particles from this emulsion to cellulose fibers is practically identical to that which is achieved in sizing with rosin. That is, after adequate dispersion alum or in some cases alum-acid is added in an amount sufficient to adjust pH value to approximately 4.5. Immediately after this is done the ordinary papermaking procedures can be carried out.

At this point the good question invariably arises, "What about retention?" There are so many factors upon which retention is contingent that this important question is rendered difficult if not an impossible one to be specifically definitive upon. These primary contingent factors are all bound up with type of pulp, molecular weight of the resin, operating temperatures, thickness of the sheet or board, beating degree of the pulp, and pH control.

In the earlier days and still in use is a practical method which determines retention simply by calculations based upon total dry end yield after initial recording of pulp plus resin input.

Other manufacturers who find it advantageous to meter resin to moving stock have developed a test which relies on cured wet-strength properties. In this case a sample is taken near the dry end and subjected to rapid infrared cure. The sample is then immersed in boiling water, to which a wetting agent has been added, for a period of 5 min. Following this, tensile and bursting strengths are noted for comparison with dry tests in order to determine wet strength. On this basis if the standard required is, say, 50% wet strength,

A. E. MOYER, Synco Resins, Inc., Bethel, Conn.

then the paper shall meet this standard. If it falls below an increase in the resin metering rate is called for, and, conversely, if the standard is exceeded then resin metering is reduced.

N. G. Long, S. E. Church, and V. Stannet in studies at Syracuse University College of Forestry developed a very accurate retention technique which we wish to summarize for the record here (*4*). The apparatus involved was a Model DU Beckman quartz spectrophotometer using quartz cells and quartz spacers and ultraviolet source from a no. 2230 hydrogen lamp.

From a handsheet preparation process a volume of white water was collected, filtered, and acidified to pH 3.0. The optical density of the filtrate, at 2800 A, was determined with the Beckman. Using this value, the resin retention was calculated, using Beers Law relationship and the following Table I.

Table I

Weight of total resin input, g	1.9625
Volume of stock slurry, ml	13,100
Optical density of white water	0.074
Conc. of white water, p.p.m.	35.0
Weight of resin in white water, g	0.459
Resin in white water, %	23.4
Retention, %	76.6

Further in these studies retentions up to 80% were obtained by use of high molecular weight resin at 5% input on unbleached kraft with precipitation carried out in the system at 20°C. Wet burst and tensile strengths of 50 to 55% and 38 to 45% were obtained after oven curing the sheets 5 min. at 150°C. These values were closely duplicated by radiant curing for $1^1/_2$ sec. with the sheets exposed 2 in. from two Radd heaters per bank.

By removal of most of the low molecular weight water soluble portions of the resin they were able to obtain retentions of 92%. In such cases, however, both wet burst and tensile values were greatly reduced, decreasing from 58 and 41%, respectively, to 33%. This is proof that factors other than high retentions are most contributory to the maximum physical properties when using the type of resin under discussion.

This phenomenon seems to be further borne out by equivalent addition of powdered beater resin which represented the ultimate in high molecular weight. At 5% input a retention of 84% was obtained and the cured sheets gave 28 and 25%, respectively, for wet burst and tensile values (*5*).

The dimensional stabilizing effect of 20% liquid resin addition to unbleached kraft was studied. The pulp had been worked to a Schopper-Riegler freeness value of 820 ml. which became 880 ml. after precipitation of the resin. From this, 130-lb. paper was made on 24 × 36—500 basis. Dimensional change was measured and given as the sum of contraction from 50% R.H. to 5% and expansion from 50% R.H. to 93% with results as shown in Table II:

Table II

% Resin	*Expansion, % (M.D.)*	*Expansion, % (C.D.)*
0	1.17	...
20	0.49	0.28

These results show considerably more than 100% hygroexpansivity removed in the machine direction. By comparison the monoesters of dicarboxylic acids and polyols studied by W. P. Ericks and R. L. Slattery (*6*) removed 48% hydroexpansivity at equivalent resin input plus 3% melamine-formaldehyde resin.

The results with the liquid phenol-formaldehyde beater addition resin seem also to compare favorably with those obtained through cyanoethylation without the accompanying decrease in physical strength shown by the latter.

Up to this point our discussion has embodied data pertinent to the addition of resin to cellulose fiber. It should be mentioned that the resins described also have a strong affinity for asbestos fibers and that by techniques identical to those employed for adding to cellulose very high resin inputs and retentions can be achieved. Mixed furnishes containing nonpolar fibers such as glass and cellulose or wool and cellulose have resin substantiveness remarkably improved by dispersing of certain cationics prior to resin addition. Among the most effective of such agents are the formate or acetate salts of fatty amines which have carbon chain lengths of 12 or more.

Among the materials of commerce mentioned heretofore one of the most interesting is fiberboard or hardboard. This type product has achieved an extremely important position in a little over a decade in large volume fields such as construction, packaging, furniture, and others and with multimillions of board feet now being produced annually important uses are still increasing with very little limitation in sight.

It is well known that phenolic resination of such boards has achieved properties that have enabled them to be used in areas where otherwise failure would be certain. This refers primarily to properties such as water resistance, dimensional stability, and strength.

Of the many classes known we wish here to refer mainly to hardboards which have been treated with low percentage of phenolic beater addition resin by a beater or wet end process before the board was formed. S. K. Swamy of Yale University studied fiberboard properties (*7*) obtaining significant comparison of properties of hot wet pressed boards containing no resin and containing 3% of a liquid phenolic of the type under present discussion. Pertinent data derived are shown in Table II.

Table III

Resin, %	*Water absorption in 24 hr., %*	*Modulus of rupture, p.s.i.*	*Swelling thickness, %*
0	49.42	6132	31.00
3	13.67	9545	9.98

The boards tested were prepared from refined asplund fiber. Pressing was carried out for 20 min. at 375°F. under a pressure of approximately 1 ton per square inch.

The percentage changes in properties obtained by the addition of 3% resin in comparison with properties of boards containing no resin show very distinct advantages. This study by Dr. Swamy also shows that hot wet pressed hardboards containing 3% resin have properties comparable or better than dry pressed boards with a much higher resin content ranging from 5 to 25%.

Another very interesting commercial possibility which has not as yet come to full fruition we believe should be the treatment of kraft papers for honeycomb cores by the beater resination process. The fact that property and economics wise this would be decidedly advantageous has been shown by work at Forest Products Laboratory (*3*). In this study the physical effects of off-machine water-soluble resin treatment is compared with beater addition. The paper employed was from a single run of unbleached kraft paper and other conditions outside of the resinating itself were kept identical. A summary of comparisons gave conclusions as follows for 20% resin inputs by size press impregnation and by beater sizing. Wet tensile strength (per cent calculated as per cent of dry strength) in machine direction for the size press operation was 55% versus 66% for the beater treated sheet.

The dry tensile values given for the size press treated

sheets were exceeded in every respect by the corresponding beater added resin values. In this 20% beater added resin gave in machine and cross machine direction 80 and 113% greater than the untreated paper.

Comparative flexibility of the papers, after cure of the resin, were evaluated by tensile tests after sharp creasing. A surprising retention of strength for the beater added resin was shown.

When the water soluble, phenolic, size press resinated papers were tested, all breaks occurred at the crease. Some specimens of the beater added resinated sheets did not break at the crease. The beater added types after creasing retained an average of 80% of their tensile value before creasing, whereas the size press treated papers averaged a retention of 63%. These values were taken for the 20% resin input sheets in the machine direction.

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Presented at the meeting of the Eastern District of the New England Section of TAPPI, held in Framingham, Mass., Jan. 11, 1960.

Gulf Coast

The Gulf Coast Section of TAPPI met Dec. 11, 1959, at the Battle House Hotel in Mobile, Ala. Total attendance was 100. Mallory D. Davis, Research, International Paper Co., served as program chairman. William Elsevier presided.

The first paper, "New Developments and Experimental Timber Combine," consisted of a film narrated by Kendall Dexter, Gulf Region conservation forester, International Paper Co., Mobile, Ala. Mr. Dexter substituted for T. N. Bush, who could not be present due to illness. He gave an excellent discussion of the operation of a newly developed tree cutting machine. The machine cuts down the tree, cuts the log into standard pulp wood lengths, strips off limbs, and stacks the wood in bundles for convenient loading on trucks. A shorter than usual stump is left by the tree cutter. Oversize tires on the machine simplify the problem of cutting and removing pulpwood from areas not convenient for truck operation.

Richard Weiberg, Research and Development, St. Regis Paper Co., Pensacola, Fla., was the second speaker. His subject was "Green Liquor Clarification," describing a continuation of previously published work by C. W. Rothrock of St. Regis. Two systems, differing in the green liquor clarification stage, were evaluated. Causticizing efficiency, settling rate in the white liquor clarification operation, reburned lime quality, etc., were compared. The settling rate of lime mud from white liquor is apparently not adversely affected by the absence of green liquor clarification. Appearance of reburned lime, and available lime content are affected to some extent by the use of unclarified green liquor. A copy of the paper is not available at this writing, but will be forwarded for publication when received.

The final paper of the evening was by A. W. Pesch, technical assistant to vice-president and manager of manufacture, Southern Kraft Div., International Paper Co., Mobile, Ala. His subject was, "Food Packaging Papers and the Food Additives Amendment of 1958." Mr. Pesch discussed the history of Federal legislation in the field of food, drugs, and cosmetics, items of interest to the paper industry, what technical paper men may do in these matters, and what might be expected in the future. His paper was of great interest to the audience as evidenced by numerous questions from the floor. The paper was published in the January issue of *Tappi*.

The Mobile meeting was concluded Saturday morning by a mill visit to Scott Paper Co., at which the new tissue machine and other recently installed facilities were inspected. This mill visit proved extremely interesting to all members of the tour.

N. M. LeMaistre, *Secretary*

Green Liquor Clarification

Richard Weiberg

Early in 1957, C. W. Rothrock, Jr., made a study of two causticizing systems. I refer you to his paper titled, "The Effect of Certain Variables on the Causticizing Process," published in the June, 1958, issue of *Tappi*. In Mr. Rothrock's study, both systems were similar, except for the following. System A had two-stage mud washing and used green liquor clarification equipment. System B had only single-stage mud washing and did not use green liquor clarification equipment. These two systems were found to give limes which differed in quality. The lime from system B had a higher sodium content than the lime from system A, and the high sodium content lime was often overburned and unreactive. I quote three conclusions from Mr. Rothrock's paper.

1. "Lime quality or reactivity is important in a continuous system where time is a factor. Lime that is overburned will be slow to slake even though the CaO content is high."
2. "Single-stage mud washing, as would be expected, does not give sufficient sodium removal. The high sodium content of mud to the kiln is felt to be largely responsible for the low reactivity of the reburned lime."
3. "Green liquor clarification . . . does not reduce the quantity of suspended solids in the white liquor nor change the composition of these solids. The removal of these dregs is thought to improve the burning properties of lime. Whether this is necessary when good mud washing is available still remains to be seen."

As a result of Mr. Rothrock's study, system B was modified by the addition of two-stage mud washing. Now systems A and B are identical except that system B still does not use green liquor clarification. In August, 1958, the two causticizing systems were again compared by examining caustic room data and by making laboratory tests on lime samples from the two systems.

Table I contains caustic room data averaged for the month of August, 1958. The Table shows the white liquor total alkali in both systems to be nearly the same. The white liquor causticizing efficiency in system A is 80.2%, a little higher than that of system B which is 77.8%. The reburned lime from system A has a higher available CaO content and a higher causticizing power than the reburned lime from system B. Although system A's lime has the higher available CaO content, it is less reactive than the lime from system B. This is shown by a comparison of the per cent free lime in the lime mud from each system. System A has over three times more free lime in its lime mud than system B.

Information derived from the above data shows very little chemical superiority in the end use of reburned lime which has had the benefit of green liquor clarification.

Table II shows a comparison of the reburned limes from the two systems. System A contains nearly 91% CaO and 0.55% Na_2O, while system B contains only 76% CaO and 0.96% Na_2O. System B's lime is a lower quality product than system A's lime.

The next comparison between the two systems concerns

Richard Weiberg, Research and Development Dept., St. Regis Paper Co., Pensacola, Fla.

Table I. Average Caustic Room Data for August, 1958

	System A	*System B*
White liquor		
"A" Test	11.6	12.0
Causticizing efficiency, %	80.2	77.8
Reburned lime		
Available CaO	86.6	83.5
Causticizing power	81.8	80.5
Lime mud		
Free Lime, % CaO	3.54	1.09

itself with lime reactivity. Figure 1 shows per cent causticizing power versus reaction time. The data for this graph were obtained by causticizing a boiling solution of sodium carbonate in water with 50 g. of lime. The lime and sodium carbonate were allowed to react for periods of 10, 20, 30, 40, 60, and 80 min. During this time, water was added to keep the volume of the solution constant. At the end of the reaction time the mixture was filtered. The filtrate was used to obtain the per cent causticizing power, and the results plotted versus reaction time.

At short reaction times, lime B has the higher causticizing power. However, as the reaction time increases, the greater purity of lime A causes it to have a greater causticizing power

Table II. Analysis of Lime Samples Over a 2-Day Period

	System A	*System B*
% CaO	90.8	76.0
% Na_2O	0.55	0.96

than lime B. Even though lime B is more active than lime A, it is a lower quality product because of the large amount of inert material that it contains.

The lower reactivity of lime A is also shown in Fig. 2. This graph shows white liquor causticizing efficiency plotted against per cent CaO in lime mud. The data for this graph were obtained by causticizing samples of green liquor with varying quantities of lime for 90 min. During this period, the stirring rate and reaction temperature were held constant. The resulting white liquor was used to determine the per cent causticizing efficiency. Lime mud samples were analyzed to determine per cent CaO.

As one can see from the graph, system A has to carry a much higher per cent free lime in its lime mud than system B to reach a given per cent causticizing efficiency.

From the mill operating data presented and the laboratory tests on lime samples from the two systems, the following conclusions are drawn.

1. Two stage mud-washing has lowered the sodium content of lime B. It is felt that this lowering of the sodium content has improved the burning characteristics of the lime.

2. The lower reactivity of lime A is probably due to a temporary overheating condition in the kiln. It is felt that

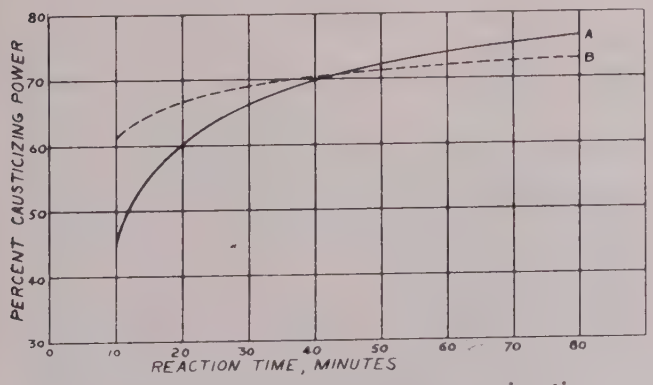

Fig. 1. Causticizing power versus reaction time

——— System A reburned lime
– – – System B reburned lime

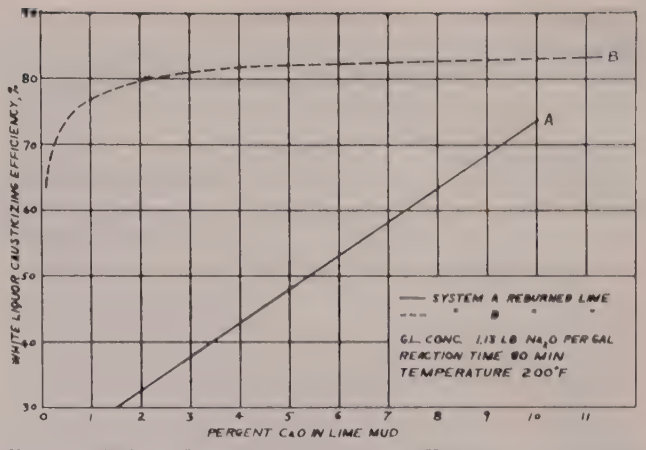

Fig. 2. White liquor causticizing efficiency versus per cent CaO in lime mud

this effect is somewhat exaggerated by the short sampling period. It is fairly certain that the lower reactivity of lime A is not caused by excessive sodium, since lime A contains less sodium than lime B.

3. From the viewpoint of available chemical tests on lime quality, it is impossible to state that there is any definite advantage to green liquor clarification, as far as causticizing efficiency is concerned. However, this conclusion does not consider operating problems such as handling the load of inert material.

Presented at the meeting of the Gulf Coast Section of TAPPI, held in Mobile, Ala., Dec. 11, 1959.

January, 1960

The Gulf Coast Section of TAPPI met Jan. 22, 1960, at the Stafford Hotel in Tuscaloosa, Ala. Attendance was 67. Arden Walker of Gulf States Paper Corp. served as local arrangements chairman. George Brabender of Marathon Southern presided as program chairman.

The first speaker was Karl Jurbergs, Buckeye Cellulose Corp. His subject was "Morphological Properties of Cotton and Wood Fibers. II. Slash Pine." This paper will be given at the National TAPPI meeting and will be published in *Tappi* at a later date.

The second speaker was Clyde Reaves of Gulf States Paper Corp. He gave a paper written by himself and Bernard Cox entitled, "Study of Brown Stock Washing."

Saturday morning the group toured facilities of the Department of Pulp and Paper at the University of Alabama.

N. M. LeMaistre, *Secretary*

A Study of Brown Stock Washing

Bernard Cox and Clyde Reaves

Over the last 20 years, many of the paper mills here in the Southeast and indeed over the nation have experienced the change from batch-type diffusers to continuous filters in brown stock washing. In the case of Gulf States Paper Corp.'s Tuscaloosa plant, the change took place at a time when outages and cost considerations demanded a rapid completion of the job with limited instrumentation. The washers were brought on line without an established training program or operating procedure. Nevertheless, the change provided increased capability and considerable reduction in soda loss and we were happy with the results.

As the demand for greater output continued, we found that at times we were maintaining washer rates with relatively high soda losses. This led to an investigation of washer performance and factors affecting washing efficiency. The specific goals of the investigation were:

Bernard Cox and Clyde Reaves, Gulf States Paper Corp., Tuscaloosa, Ala.

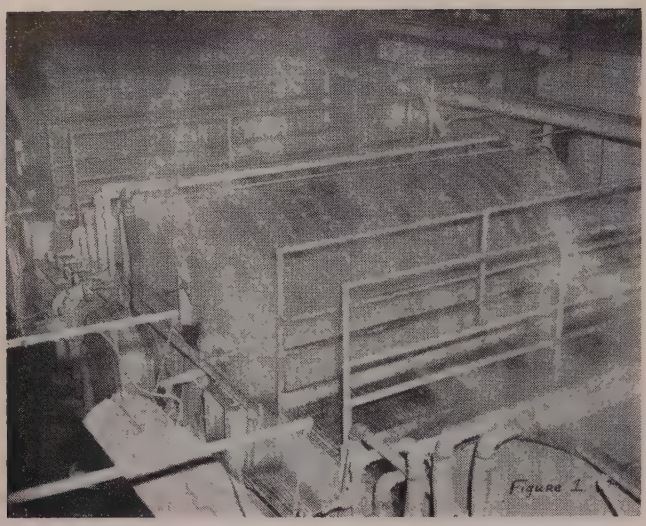

Fig. 1

1. To determine washer capability at various rates of soda loss.
2. To evaluate the effects of process variables with a view toward determining optimum operating conditions.
3. To develop an effective procedure for operating the washers.

EQUIPMENT AND PROCEDURES

At the time of this investigation, stock washing facilities at Gulf States' Tuscaloosa plant consisted of a three-stage continuous rotary filter system operated in parallel with a set of 12 diffusers. Data on the continuous washing system are as follows:

1. Brown stock is pumped from the blow tank at 5% consistency to three Impco washers in series. Washing takes place under countercurrent operating conditions with hot water (140 to 150°F.) entering the showers of no. 3 washer and pulp-black liquor entering at no. 1 washer. In order to decrease fiber loss from the diffuser system, strong liquor from the diffusers is added to the stock as it enters no. 1 washer. An overall view of the washers is shown in Fig. 1.

2. The three washers have the same dimensions and are 8 ft. diam. and 12 ft. wide. Vacuum is maintained in each by a 25-ft. gravity log. Washer drum rate can be varied from 0 to 4 r.p.m.

3. Filtrate from each washer exits through the gravity leg to a 25,000-gal. storage tank. From there it is pumped by a 2400-g.p.m. centrifugal pump to the showers of the preceding washer. A portion of this filtrate is recycled back to the washer to control incoming pulp consistency. Thus, part of the filtrate flow from no. 3 washer to the showers of no. 2 washer is diverted back to the tub of no. 3 washer, etc.

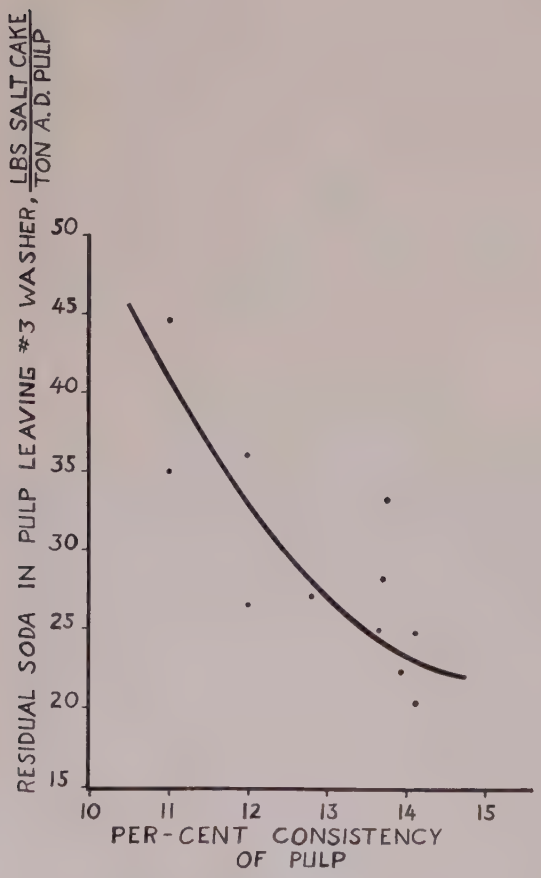

Fig. 2. Scatter diagram of residual soda in pulp leaving no. 3 washer versus per cent consistency of pulp

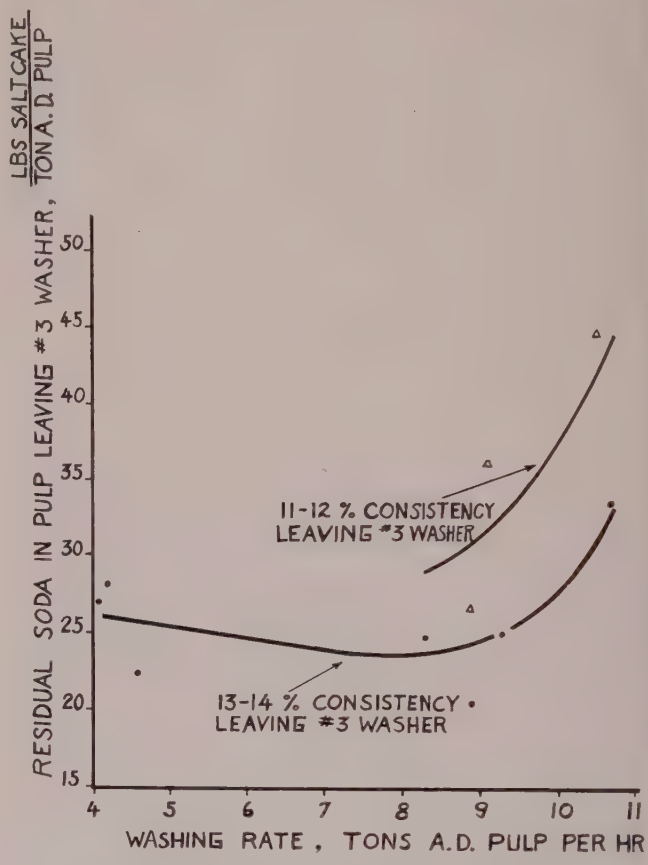

Fig. 3. Scatter diagram of residual soda in pulp leaving no. 3 washer vs. washing rate, tons air dry pulp per hr.

4. The rated capability of the washing system is 11 tons airdry pulp per hr. with a liquor output of 400 g.p.m. at 6° Bé. and 180°F.

With this information as a background, we set up a program for experimental operation of the washers. The overall plan of the program was to operate the washers at various stock throughput rates while simultaneously varying shower and dilution rates. Thus for a given stock throughput, several runs were made, each at a different shower rate. Individual runs lasted approximately $2^1/_2$ hr. in order to attain equilibrium conditions. The description of a typical run is as follows:

After adjusting input from the blow tank to the approximate tonnage rate desired, washer r.p.m. and shower flow rates were set for all three washers. Recycle valve settings were made such that a constant pulp-liquor level was maintained in the washers.

When the desired operating conditions had reached equilib-

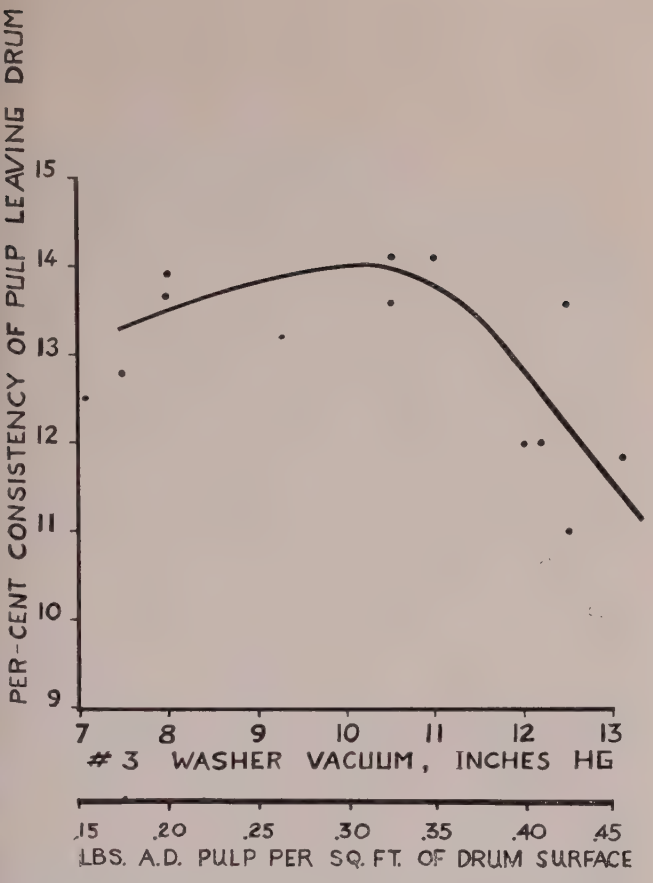

Fig. 4. Scatter diagram of per cent consistency of pulp versus no. 3 washer vacuum, in. Hg and lb. air dry pulp sq. ft.

rium, samples and readings were taken for the following data:

1. Incoming stock consistency.
2. Exit liquor flow rate, Baumé, alkalinity, and total solids.
3. Outgoing pulp flow rate, consistency, and residual soda.
4. Washer speed, drum vacuum, shower flow rate, and recycle setting.

From these results, several plots were made in order to determine the effects process variables had upon washing efficiency and stock throughput. The most significant of these effects is presented in Figs. 2–6.

DISCUSSION

Figure 2 shows that pulp consistency leaving the washer plays a major role in the amount of residual soda remaining

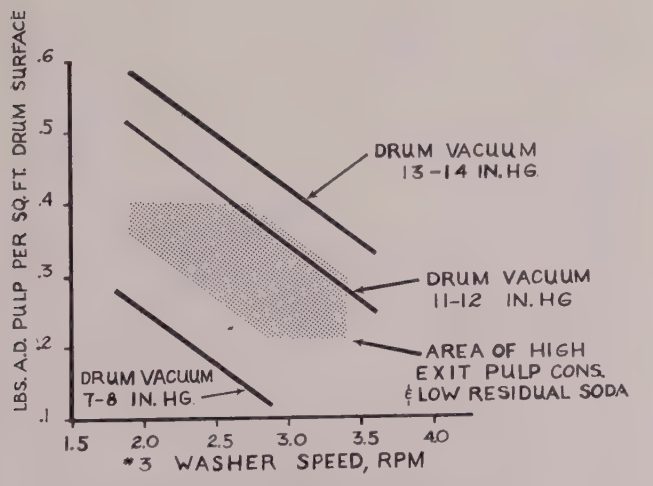

Fig. 5. Diagram of pounds air dry pulp per sq. ft. versus no. 3 washer speed, r.p.m.

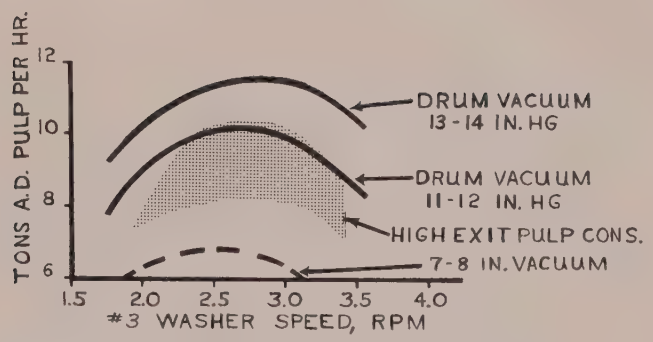

Fig. 6. Diagram of tons air dry pulp per hr. versus no. 3 washer speed, r.p.m.

with the pulp. Thus, as exit pulp consistency increases, there is a marked drop in soda loss. These phenomena lead to the conclusion that a large part of the residual soda in washed stock is held in the solution of the mat rather than bound to the fiber itself.

This effect is further illustrated in Fig. 3 which shows the effect of washing rates upon soda losses at different exit pulp consistencies. It is apparent from this figure that washing rate can be increased with very little increase in soda loss until the maximum capability of the washers is approached. At that point there is a sharp rise in soda loss with a considerable decrease in washing efficiency. Again we see that a high exit pulp consistency allows a greater washing rate for the same soda loss.

With regard to Fig. 4, we see the effect of washer vacuum and mat thickness upon exit pulp consistency. Thus as washer vacuum increases, there is a corresponding increase in mat thickness (pounds airdry pulp per square foot), but this does *not* necessarily hold true for pulp consistency. The effect of washer vacuum upon pulp consistency passes through a maximum and then drops off as vacuum is increased.

The presence of higher vacuum enables more pulp to be picked up on the drum; but as the pulp passes under the showers, the increased mat thickness causes the pulp to retain more water per pound of fiber.

Figures 5 and 6 illustrate the effects of washer speed upon mat thickness. As may be expected, an increase in speed causes a corresponding decrease in mat thickness for the same drum vacuum. It is interesting to note however that increasing speed does *not necessarily increase* throughput rate (see Fig. 6). The combination of increasing speed and decreasing mat thickness creates a maximum point of throughput for a given washer vacuum. Of course, as vacuum is increased, washer throughput can be increased. The shaded areas in Figs. 5 and 6 show the points at which highest exit pulp consistency is reached. This is in line with the trends shown in Fig. 4.

In view of these graphs (see Figs. 3, 5, 6) results indicate that the optimum sustained capability of the pulp washers is $10^1/_2$ tons airdry pulp per hr. This corresponds to a soda loss of approximately 30 lb. salt cake per ton of pulp. Using this and the other information gained from the washer runs, operating procedures were developed for production use. Later trials of these procedures have indicated that at full load, soda losses can be reduced by 4 lb. salt cake per ton of pulp. This constitutes a saving for us of approximately $10,000 per year.

CONCLUSIONS

Experimental runs with continuous rotary brown stock washers have shown that:

1. Residual soda losses decrease as exit stock consistency increases. Thus a large portion of the residual soda is dissolved rather than attached to the pulp.
2. Increasing washer vacuum does not necessarily in-

crease exit stock consistency. A maximum is reached beyond which consistency falls off.

3. Increasing washer r.p.m. does not necessarily increase stock throughput (vacuum being the same). This is caused by the overriding effect of decreasing mat thickness. However, stock throughput can be further increased by increasing drum vacuum.

4. Using the procedures discussed, the optimum sustained washing rate was determined and washing procedures were developed.

Presented at the meeting of the Gulf States Section of TAPPI, held in Tuscaloosa, Ala., Jan. 22, 1960.

Fiber-to-Fiber Bonding and Beater Adhesives

John W. Swanson

Each year a wide variety of papermaking problems are brought to The Institute of Paper Chemistry. These problems run the gamut of the paper and board processes from genetically producing a more suitable wood, to the converting and end use properties of the final product. I am sure that it will not seem strange to you that a large majority of these problems involve the strength properties of the fibrous structures in one way or another. Perhaps the question most frequently asked is "How can the strength of our product be improved?" From an operational standpoint a great many factors are known that will change the ultimate strength of the product. Very often, however, the operational changes must be reduced to their effects upon the basic factors responsible for paper strength. Otherwise the benefit received in one property may be offset by a detrimental effect upon another property. This is particularly true where certain beater additives are employed for correcting a problem. For example, a manufacturer of an absorbent paper product may find it desirable to add a surfactant to his furnish in order to assist rewetting or to combat self-sizing. He may find that sufficient surfactant to offset self-sizing reduces strength to an intolerable level or produces undue foaming. In another problem he may add a beater adhesive to improve bonding in a filled sheet but finds that retention becomes so poor that the optical properties are deficient. In each case an understanding of the effect of these additives upon the basic factors responsible for strength would permit the desired results to be obtained.

At this point you may ask—what basic factors are we talking about—what are the factors basic to the strength of paper? A complete answer would be complex and could lead to a lengthy discussion. Undoubtedly some of the basic factors are at present unknown or unrecognized. Briefly, however, we know that the following are important.

Fiber length
Fiber strength
Bonded area
Bonding strength per unit area
Distribution of bonds (sheet formation)
Stress distribution
Fiber conformability

With the possible exception of fiber length it might be said that all of the factors involve some aspect of bonding, either between fibers or within the fiber itself. The important considerations then in any strength problem are (a) what will be the effect upon fiber bond strength and (b) what will be the effect upon the other factors mentioned above.

In our work with various beater adhesives and other wet end additives we have found it quite important to have an understanding of the mechanism of interfiber bonding. Recent work in this field now gives a clearer picture of the several mechanisms involved in the development of sheet strength from the wet-web stage to the final dry paper. At this time, I should like to set forth a picture of fiber bonding and then to illustrate how this information can be useful in strength problems involving beater adhesives and, perhaps, other wet-end additives.

John W. Swanson, Senior Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

The Nature of Adhesion and Its Role in Fiber Bonding

The theory that the strength of paper resides in mechanical entanglement and frictional effects of fibers and fibrils has now been largely disproved. The following facts support this idea.

1. When water in a wet sheet is displaced by an organic solvent and the sheet is dried, very little or no strength exists.

2. When the water in a wet sheet is frozen rapidly and sublimed below the freezing point the sheet is very weak.

3. Sheets formed from pulps suspended in dilute solutions of surfactants are very weak.

4. Certain pulps which fibrillate extensively upon beating will not yield strong paper even when both the beating and sheet preparation are done in water.

5. Perhaps most convincing of all—load-elongation studies show that papers exhibit both "primary creep" and "secondary creep." Strain-hardened papers from which secondary creep has been removed may be repeatedly strained and relaxed without damage to their structure. This would hardly be expected if paper strength depended primarily upon frictional effects.

It is now well recognized in the field of adhesion that secondary molecular forces are of major importance in bonding similar and dissimilar materials together.

Fundamentally, bonding as well as sorption of water and many other materials in the papermaking system occurs because of the fact that all atoms and molecules attract each other with characteristic forces, called valence forces. These valence forces are of two types—primary and secondary.

Primary valence forces are those which are responsible for actual chemical compound formation. They involve energy changes of the order 10 to 100 Kcal. per mole. The nature of this type of bond varies from actual electron transfer from one atom to another in electrolytes or ionic compounds, such as NaCl, to the sharing of electrons between atoms in the formation of covalent bonds in organic compounds, and to the swarming of electrons in the metallic bond such as Na_2.

When the primary valence forces have been utilized in forming a molecule or chemical compound, residual attractive forces still exist between the molecules. These are the so-called secondary forces on Van der Waal's forces which lead to the aggregation of molecules into liquids and solids and the various crystalline forms of matter. Formation or rupture of such bonds involves energy changes of 0.5 to 10 Kcal. per mole. These residual forces are exerted in all directions from a molecule and are of three main types.

1. The Keesom or orientation forces which exist between rigid dipolar molecules.

2. The Debye or Induction forces which result from the action of dipolar molecules on a polarizable nonpolar molecule.

3. The London or dispersion forces which exist between all types of molecules—polar as well as neutral.

The equations expressing the attractive energies for these three effects are presented below.

$$U_0 = -\frac{2\mu^4}{3KTr^6}$$

$$U_I = -\frac{2\alpha M^2}{r^6}$$

$$U_D = -\frac{3h\nu_0\alpha^2}{4\,r^6}$$

where

μ = dipole moment
k = Boltzman's constant
T = absolute temperature
r = distance between the molecules
α = polarizability of the molecule
h = Planck's constant
ν_0 = characteristic frequency of the molecule

The forces of attraction corresponding to the above energies may be obtained by differentiation of the equation with respect to the distance.

The induction effect (ν_I) is small for most molecules. The London effect (ν_D) always produces considerable molecular interaction; but the orientation effect (ν_0) is of major importance with substances possessing a relatively high dipolar character.

There is a special case of the orientation effect when a H atom is attached to a strongly electronegative atom such as N, O, the halogens or sulfur. Where the geometry of the molecule is favorable, the H is shared between two such electronegative groups. This is called the hydrogen bond. Such H-bonds have energy values of from 3 to 8 Kcal. per mole depending upon the particular atoms and the distances involved.

The important consideration here is that these forces of attraction are exerted in all directions. This means that molecules existing in the surface layer of solids and liquids and upon the corners and edges of solids are not satisfied in one or more directions. Thus, whenever a solid is placed in the vicinity of a gas, vapor, or liquid, or even another solid, there is a strong tendency for the surface molecules of this solid to satisfy their residual attractive forces. This behavior results in the phenomena of adsorption and absorption as well as flocculation of materials possessing high specific surface. These forces are also responsible for adhesion of solid high polymers when sufficiently intimate contact on a molecular scale can occur.

The pertinent facts to bear in mind for fiber bonding are the following:

1. Hydroxyl groups viewed on a molecular scale are strongly polar.
2. Pulp fibers have a multitude of hydroxyl groups potentially capable of interaction by the orientation effect and hydrogen bonding as well as by the London or dispersion effect.
3. The attractive forces mentioned above decrease with the inverse seventh power of the distance. Therefore, elements of the fiber which are to be bonded together must approach one another very closely if these forces are to become effective. The distance of separation should be no more than a few Angstrom units.
4. Rigid solid surfaces are very rough and the real area of contact on a molecular scale when two such surfaces are brought together is very small.

It is clear, therefore, that one of the most important aspects of papermaking is to prepare the fibrous material in such form that intimate contact between fibers and fibrils can occur on a molecular scale. This is one of the primary reasons for beating and refining pulps. It is also one of the basic reasons for the use of beater adhesives. Such materials are able to bridge distances between fibers and establish bonds that would not have otherwise formed. Now let us examine some of the evidence that intimate contact is necessary for good fiber-to-fiber bonding.

THE EFFECT OF SWELLING ON FIBER BONDING

It is fairly well established that pulps which swell rapidly and to the greatest degree, tend to form better bonds as indicated by physical strength measurements of the paper. The role of swelling in the beating and bonding of cellulose fibers was clarified many years ago by the work of Kress and Bialkowsky (*1*). These workers attempted to show that the swelling action of water on papermaking fibers was unique. They used a low-pressure dilatometer to measure the volume swelling of compressed disks of cellulosic materials brought into contact with various solvents. They found, contrary to the original postulation, that water was not unique in its swelling action; a great many liquids swell cellulose extensively. Formamide gave a swelling volume of 125% as compared with 90% for water, 62% for methanol, 4% for *n*-butyl alcohol, and 2% for fuel oil. They subjected cellulosic fibers (unbleached Mitscherlich spruce sulfite pulp) to beating action in the various liquids, made photomicrographs of the beaten pulps, and prepared handsheets and measured their strength properties. It was apparent that those liquids which caused appreciable swelling of the pulp also gave a decidedly different beating action than liquids which do not permit extensive swelling of the pulp. Fibers beaten for various times in water were very highly fibrillated and entangled with one another. Fibers beaten in fuel oil or butyl alcohol were chopped in small pieces and no evidence for fibrillation could be seen. These workers further showed that fiber bonding would not occur if the fibers were beaten and formed into a sheet in a nonswelling liquid. They concluded that, among the liquids studied, those which have a hydroxyl or a potential hydroxyl group and a high dielectric constant produce a high rate of swelling as measured by the dilatometer; these same liquids also "hydrate" stock on beating as measured by sheet strength, freeness, etc.

Further clarification of the role of swelling and shrinkage in fiber bonding is furnished by the works of Bletzinger (*2*), Aiken (*3*), Harrison (*4*), and McKenzie and Higgins (*5*) on acylated pulps. These workers showed that acetylated and butylated pulps beaten in water in general became stronger up to about 4 to 6% acyl and then much weaker as the acyl content increased and swelling in water became negligible. However, when a pulp of 25% acetyl content was beaten in acetone or benzene-water emulsion in which the pulp could swell, a paper was obtained which was stronger than that made from the original unacetylated pulp beaten in water. Harrison (*4*) found an additional interesting fact with the stearoylated pulps. Even though swelling occurred in an organic solvent, bonding would not occur presumably because the long hydrocarbon chains would not permit the polar groups to approach sufficiently close.

THE EFFECT OF HEMICELLULOSES ON FIBER BONDING

It is well known today that the bonding or strength properties of a particular type of pulp increase regularly with hemicellulose content up to a certain maximum. The work of Young and Rowland (*6*) shows a positive linear relationship between the swelling capacity of a softwood pulp and the pentosan content. A similar relationship for beech hardwood pulps is shown by Jayme and Lochmüller-Kerler (*7*). Many other workers such as Obermanns (*8*), Ratliff (*9*), March (*10*), Wise (*11*), and Cottrall (*12*), have confirmed the relation between rate and extent of swelling of pulp fibers and their hemicellulose content. Generally speaking, hemicelluloses can be said to improve bonding by increasing both the rate and extent of swelling which increases contact and polar bonding on a molecular scale. Both March (*10*) and Jayme and Lochmüller-Kerler (*7*) found that the strength properties of hardwood pulps increase with hemicellulose content up to a maximum of 26%. Higher values gave lower sheet strength. Quite possibly both the bonded area and number of bonds or bond density increase up to the maximum, but beyond this point, bonds become brittle and the lower molecular weight material decreases fiber bond strength. Young and Rowland also have an explanation for the maximum. They maintain that the hydrogen bonds arising from the secondary hydroxyl groups of the pentose units of the hemicelluloses are weaker than the hydrogen bonds obtained from the primary hydroxyl groups

of the hexose units of cellulose chains. Thus, although the smaller amounts of hemicelluloses may increase greatly the number of hydrogen bonds and, therefore, the bond density, the greater quantities of hemicellulose ultimately form bonds almost entirely of material which is inherently weaker.

THE EFFECTS OF DRYING AND HEATING ON SWELLING AND BONDING

There are two other aspects of fiber swelling which are often of interest to the papermaker. One of these is concerned with the effect of previous drying of the cellulose fibers and the other is concerned with the effect of temperature.

When a sample of cellulose pulp which has never been previously dried is gradually conditioned at various lower relative humidities down to essentially zero moisture content and is then permitted to readsorb moisture, the desorption and adsorption curves do not coincide. The desorption curve lies above the adsorption curve. This behavior is called *hysteresis*. The swelling of cellulose fibers closely parallels these two curves. The hysteresis is believed to be caused by new hydrogen bonds formed within the fiber during drying which do not break when subjected to water vapor. This behavior has a practical aspect in that dried pulp will never yield as strong a paper as a never-dried pulp presumably because previously dried pulp never achieves as high a degree of swelling. Thus, the papermaker must, in many cases, decide whether to buy dry lap and sacrifice strength or buy wet lap and pay the extra freight. This effect is also one of the reasons why recovered broke will not produce as much strength as virgin pulp. The effects of previous drying on fiber swelling and sheet strength have been studied by Lyne and Gallay (*13*). These workers found a linear relationship between the percentage decrease in bursting strength and the dryness of the pulp. For pulps that had been essentially bone dried the loss in bursting strength amounted to approximately 85% of the strength of the original never-dried pulp. However, they also showed that subsequent beating and refining of the dried pulp in water will recover a significant part of this strength loss.

When cellulose sorbs water, the fibers swell in volume and heat is given out. This is expressed thermodynamically in the following equation,

$$\Delta H = \Delta F + T\Delta S$$

where ΔH is the heat of sorption, ΔF is change in free energy, T the absolute temperature, and ΔS the change in entropy. To one versed in the field of thermodynamics, this equation implies that the adsorption process is exothermic or gives out heat. The reasoning is as follows: ΔF must be negative otherwise the sorption process would not be spontaneous; ΔS must also be negative because the molecules of water lose one degree of freedom when adsorbed. Therefore, ΔH must be negative and the process is exothermic. Now according to Le Chatelier's principle (when a stress is placed upon a system in equilibrium the system reacts in a way to relieve the stress) increasing the temperature at constant relative humidity should decrease the amount of water sorbed. This is found to be the case for cellulose and water. Therefore, pulp beats more slowly at higher temperatures, and paper made from stock at higher temperatures is generally weaker.

Now we might ask the question—If the swelling of the fibers affects the strength of the final paper how is this accomplished? A wet sheet made even from highly swollen fibers is still weak after very extensive pressing. Thus, there must be very few fiber to fiber bonds formed during the pressing operation *or* the fibers must spring back thereby breaking any bonds which were formed during pressing. There must be, then, some mechanism which brings the fibers into intimate molecular contact during the drying operation. A general theory for this effect was formulated by Campbell (*14*) many years ago and recently experimental data have confirmed the hypothesis. This is now known as the Campbell effect.

Briefly, the mechanism of this effect may be explained as follows: According to the fundamental law of capillarity (*15*) the pressure on the concave side of any curved liquid meniscus is greater than on the convex side by an amount which depends upon the free surface energy (surface tension) of the liquid and the radius of curvature. This is the same law that governs the rise of liquids in capillary tubes. When the water content of the wet web is high and the water level is just beginning to recede into the structure, menisci begin to form. This is a period of compaction and dewatering of the sheet part way down the fourdrinier wire just after the web has lost its sheen. The force of compaction is proportional to the surface tension of the liquid and the total length of line of fiber-water-air contact. If one assumes that the fibers are 3×10^{-3} cm. diam. and parallel, with spaces between them equivalent to the fiber diameter, there would be a total of 166 cm. of fiber length in each square centimeter of surface. The surface tension forces of water would cause an inward pull on the fibrous structure of 75 dynes per cm. or 0.15 g. per cm. or 24.9 g. per sq. cm. This would be equal to about 10 in. of water. Now, if fibrillation, as a result of beating, reduced the average fiber diameter to 0.1, the above figure and the spacing were reduced in proportion, the pressure would be 10 times as great. Although this pressure is appreciable, it is probably not great enough to produce much fiber-to-fiber bonding.

As further water leaves the sheet a situation is reached wherein there is insufficient water to saturate the internal structure of the sheet. In this situation there will be a layer of water held between those fibers which are more or less parallel to one another. Because there are now two menisci involved, one on each side of the adjacent fibers, the consolidating force exerted upon the fibrous structure will be double that exerted in the previous case. This force is not unusually great either. However, this effect is responsible for the development of appreciable wet-web strength as we shall see in a few moments.*

Eventually during the drying process there will be only sufficient water for a small circular film between fiber elements. In this case, the compacting pressure changes from a dependence upon the total length of line of contact per square centimeter to a dependence upon the thickness, X, of the film of water between the fiber surfaces. Most everyone has had the experience of attempting to pull apart two glass plates which have a thin film of water between them. This is the same effect. From the approximate equation $\Delta P = 2\gamma/X$, where γ is the surface tension, X the thickness of the water film, and ΔP the compacting pressure, it may be seen that as the film becomes progressively thinner during drying, the compacting pressure can become very large. For example, if we assume that the surface tension of water is 75 dynes per cm. and that the film in the later stages of drying is approximately 75 A thick, the compacting pressure is about 200 atm. According to Campbell this is the major effect which brings the fiber elements sufficiently close together for molecular bonds to form during drying. Of course, at any particular moisture content and degree of beating the rigidity of the fibers and the Campbell effect will balance one another. As fibrillation increases, with the degree of beating, the average fibril diameter becomes smaller. The rigidity of a beam supported at the ends varies as the fourth power of the cross-sectional diameter. Thus, as beating proceeds the effectiveness of the Campbell pressure becomes much greater because the fibrils become much

* It should be emphasized that this version of Campbell's theory is greatly simplified. For a more exact treatment of the subject, see Campbell, W. B., "The Cellulose-Water Relationship in Papermaking," Canada, Dept. of Interior, *Forest Service, Bull.* No. 84 (1933).

more flexible and deformable. This results in better fiber bonds and greater fiber-to-fiber bonded area.

The validity of the Campbell effect has been confirmed by Van den Akker (*16*) and more recently by others (*17*, *18*). He showed that if the water in a wet web is rapidly frozen and then sublimed below the freezing point the resulting sheets are very weak. Under these conditions the surface forces do not exist or are not effective and the Campbell effect is inoperative. Similarly, we should expect that if surfactants are used in the furnish, lower strength should result because the surface tension of the water will be lower. This is found to be the case.

This entire picture of fiber bonding during the drying of paper has been clarified quite well recently by the work of Lyne and Gallay (*13*) in their studies of wet-web strength. Their tensile strength-moisture content curves show several stages of strength development.

In the first stage beginning where the sheet is about half way down the wire and the fiber content is about 8%, the web is held together by surface-tension forces arising from the menisci formed as the water layer recedes into the fibrous structure. As we stated before, these forces are proportional to the total length of line of fiber-water contact and apparently increase steadily up to a solids content of about 20 to 25%. At this point, however, the total surface-tension forces begin to decrease very rapidly. In this region the water content becomes low enough that there is insufficient forces to form a continuous film. The surface-tension forces change from a dependence upon the total length of line of fiber-water contact to an inverse proportionality to the thickness of the liquid film. Then, because of the compacting pressure, sheet density increases and interfiber bonding begins to occur. This effect rapidly promotes fiber-to-fiber bonding and sheet strength increases to the final value.

The several stages of strength development may be more clearly separated by using fibers which are incapable of forming hydrogen bonds but which are of comparable diameter. It is noted for 2.5 μ glass fibers in water that only the surface tension forces hold the sheet together until the water content gradually becomes so low that strength decreases and finally is essentially zero because hydrogen bonds do not form. However, if an adhesive capable of forming polar bonds is present, then it is observed that the final stage is effective and permanent bonds form. This is evident for the glass fibers treated with sodium silicate and gelatin.

Similarly, Lyne and Galley (*13*) observed that lowering of the surface tension of the water in the wet-glass web causes a decrease in the wet-web strength even in the region where hydrogen bonding does not normally occur to an appreciable extent.

Their curves showing the effects of sodium silicate and gelatin on glass fibers illustrate the general effect of beater adhesives such as starches, gums, mucilages, and synthetic polymers. It is well known that where these materials are properly employed, paper strength is increased to an amazing extent considering the small amount of material used.

As little as 0.5% of locust bean gum based upon the fiber weight yields paper having the same strength as paper made from fiber beaten three times as long. This represents a saving of more than 60% in power. Further methods of using such gums and adhesives have been investigated by Swanson (*19*).

REASONS FOR THE USE OF BEATER ADHESIVES

Beater adhesives are used primarily for improving bonding strength between papermaking fibers. However, this benefit may be utilized in various ways among which may be the following:

1. The improvement of bursting and tensile strengths and folding endurance, as well as tearing strength, by the addition of a small percentage of the beater adhesive directly to the refined pulp.

2. Utilization of higher percentages of short-fibered pulps and pigment fillers at constant sheet strength.

3. Decreased refining or power requirements.

4. Increased mill capacity by speeding up pulp refining.

5. Increased production by increasing machine speed through faster draining on the wire.

6. Attainment of better fiber distribution or sheet formation through the use of beater adhesives.

7. Attainment of combinations of properties otherwise difficult to obtain in a given furnish. For example, a combination of high strength and high porosity in paper is uncommon except where beater adhesives are employed.

8. The improvement of wet strength through the addition of resins or other beater adhesives.

It has been shown by a number of investigators that the more efficient beater adhesives are physically adsorbed by the surfaces of cellulose fibers and it is quite clear that the layer of highly solvated polymer on the fiber surface improves bonding by enhancing molecular contact of the surfaces.

Those who have had some experience with beater adhesives may have some rather disconcerting questions at this point. Probably the essence of most of these questions can probably be expressed in a single question—why don't beater adhesives work in our mill?

Most people are aware today that a mannogalactan gum such as Lycoid, Mannogal, Galactosol, Guartec, Burtonite, or a starch-gum mixture such as Stargum will work quite effectively on a given paper stock in the laboratory but in the mill the performance may be disappointingly poor. The explanation in a given instance will depend, of course, upon a variety of furnish and machine conditions. In some cases we have no explanation. However, in a majority of such problems a close examination of the entire mill system has resulted in much improved mill performance. Here again we must return to fundamentals.

1. Is the gum retained? Studies have shown that retention occurs onto the surfaces of practically all pulps by physical adsorption if the fibers have been at least slightly beaten.

2. However, it has been found that such materials are sorbed at rates and in amounts depending upon the specific surface area. This was investigated recently by a radiochemical tagging of the gum. This was done by methylating locust bean gum to about 3% methoxyl with methyl iodide containing carbon-14. This tagged gum was sorbed onto some moderately beaten coniferous sulfite pulp and handsheets were prepared. The fines in the white water and the white water itself were also analyzed for radioactive carbon. This study showed that at low percentage additions (0.1 to 0.5% based on the fiber) the total sorption is high *but* it was found that at 0.1% gum the fines sorbed 24% of the total gum. This means that the surfaces of the longer fibers sorbed 0.07% gum but the fines sorbed about 2% gum based upon the cellulose solids. Similarly, at higher percentage additions the fines sorbed a significant fraction of the additive. In general, both the rate and amount of sorption of such gums are direct functions of the specific surface. Clay and other high surface area components of the furnish also may effectively compete with the long fibers for the gum. Thus, it is found that furnishes which contain large quantities of fines, fillers, or filler pulps generally respond poorly where gums are added to the whole furnish.

However, if the gum is added to the furnish before the white water solids are returned or the clay or filler pulp are added, the response to gum is much improved. This permits the longer fibers to sorb the maximum quantity of gum onto the long fiber component of the furnish where it does the most good for sheet strength. The order of this effect for a sulfite-soda pulp furnish under ideal conditions has been demonstrated by Swanson (*19*).

The next most important consideration is the mechanism of the improvement of sheet strength resulting from the

adhesive retained by the longer fibers. One of the most important studies in this field is that of Leech (*20*) who investigated, for his Ph.D. thesis, the reasons for increase in paper strength when locust bean gum is used as a beater adhesive. He suggested that the strength of paper depends upon four factors; the *strength of fibers*, the *strength of fiber-to-fiber bond*, the *number of bonds* (*bonded area*), and the *distribution of bonds* as indicated by the fiber distribution of sheet formation. He further suggested that beater adhesives must increase the strength of paper by affecting one or more of these four factors. He utilized the optical method of Parsons (*21*) and Ratliff (*9*) for determination of bonded area, The Institute of Paper Chemistry bonding strength tester for bond strength (*22*), the Thwing formation tester for bond distribution, and the zero-span tensile test for fiber strength. With this information he was able to separate and assign a value to each of the contributions to the over-all improvement in strength. The contribution of each factor was as follows: increased bonded area, 15%, improved formation, 25%, increased bonding strength, 60%, increased fiber strength, 0%. The relative contributions of each factor may change to some extent with degree of refining, composition of furnish, and certain machine conditions. However, these figures may explain why beater adhesives sometimes function poorly.

For example, a beater adhesive which does not simultaneously function as a good fiber deflocculating agent as well as a good bonding agent will almost invariably be inferior. This is probably the reason cornstarch does not do a better job particularly on long-fiber unbleached kraft pulps.

It has been learned comparatively recently that low additions of certain of these gums, e.g., 3 lb. per ton (0.15%), will actually cause pronounced flocculation of fibers and fines in the system. This behavior is presently used in several mills for improving filler retention. Such flocculation in an unloaded furnish, however, can be quite detrimental to the over-all strength because not only is the 25% contribution of better bond distribution lost but in many instances bond distribution is worse than if the gum were not present. This, of course, detracts from the contribution of improved fiber-to-fiber bond strength and the over-all improvement in sheet strength becomes a borderline case. This is often encountered where beater adhesives are used for machine speed-up. Here the refining is normally reduced, this results in poorer sheet formation, and a very low percentage of gum addition makes fiber flocculation worse. The presence of alum also tends to increase fiber flocculation. Thus, if the fines are recirculated to the furnish before the gum is added, these not only decrease the bonding strength but they often flocculate periodically and cause fluctuations in strength and other properties.

Larger quantities of gum, for example, 0.5 to 1.0%, will invariably cause fiber and filler dispersion unless the fines content is excessive. At present it is not always possible to predict the exact concentration where flocculation stops and dispersion begins. Further work must be done on this subject.

Thus, any new situation for a beater adhesive must be studied carefully from the standpoints of point of addition, level of addition, other additives, refining, tightness of the white water system, and many other factors before optimum results can be obtained. In many instances where apparent failure has been encountered, such an analysis of possible effects has led to successful use of these materials.

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Presented at the meeting of the Indiana District of the Ohio Section of TAPPI, held in Indianapolis, Ind., Sept. 15, 1959.

Italian Section

Sixty-five members of the Italian Section attended the general meeting which took place in Turin on Dec. 15, 1959, in the course of which the members of the "Groundwood Committee" delivered their reports on the work carried out in 1959.

The Groundwood Committee have tried to summarize and define the meaning of groundwood quality and to show the most suitable analytical methods to determine this quality. In the report the analysis methods were described, which are thought as susceptible of being adopted on account of their following requirements:

1. The capacity to supply numerical values having a definite physical meaning to be easily and immediately understood so as to allow a prompt utilization;
2. A ready and easy achievement which allows to intervene in the fastest possible way on the manufacturing process in order that the occurrence of a long period of oscillation in the product quality may be eliminated;
3. The quality index which may be indicative not only in the considered field, but also of other quality indexes, with a reasonable approximation;
4. The cost of the test inclusive of equipment, labor employment, maintenance, which may allow their use to the greatest possible number of people concerned having or not both equipped laboratories, and qualified staff at their disposal.

The methods which were taken into consideration apply prevailingly to the examination of wet pulp; they are the methods of Brecht and Klemm as well as that based on length, fineness and cohesion indexes, supported by Clark.

The Groundwood Committee have also suggested that the above methods should be examined, applying them to the current productions of Italian poplar, and the committee have also developed a program of studies on specimens coming from different mills, expecting then, at the end of this work to draw exhaustive conclusions on the ground of which an actual report can be drawn up on the groundwood controlling methods, supported by a practical experience.

Meeting of the Italian Section, TAPPI, Dr. Piero Bersano, Chairman

The report was read by the chairman of the Groundwood Committee, Domenico Borruso,* with the help, in the working out of such report, of the members of the committee, namely: Guido Angiolini, Franco Bossi, Giorgio Ceragioli (Secretary), Giorgio Cerio, Pietro Forte, Giuseppe Pellegrini, and Alfredo Tabacchi.

Short additional reports on groundwood were also delivered to complete the basic one by the following members: F. Bossi, P. Forte, G. Pellegrini, and A. Tabacchi.

The opening lecture was delivered by the chairman of the Italian Section, Piero Bersano, who summarized the activities shown in 1959 and also pointed out that the Italian members, amounting to 180 during 1959, are now increased up to 210 active members and 97 affiliated members.

Sandro Cirla thanked Mr. Bersano, on behalf of all the members, for the work done in 1959, pointing out the recognized importance of the Italian TAPPI Section in the national paper industry.

Votings have then followed for the appointment of the officers for 1960, who are as follows:

Piero Bersano (Cartiere Burgo)
Giorgio Cerio (Cartiera Italiana)
Pietro Ghisoni (Cartiera Vita Mayer)
Vittorio Gilbeati (Cartiere Donzelli)
Alessandro Restagno (Cartiere Burgo)
Leto Ridi (Poligrafico dello Stato)
Giuseppe Villa (Cartiere Villa)

ALESSANDRO RESTAGNO, *Secretary*

* Representing Mr. Centola.

Maine-New Hampshire

Considerations in Choosing a Centrifugal Cleaner

Karl Dornish

OUR experience with centrifugal cleaners has been as pulp cleaners rather than paper stock cleaners and this discussion is centered on this experience. A little background as to how we acquired our experience with centrifugal cleaners may be in order.

You will remember that 1957 was the start of the last recession from which the economy is just now emerging. The paper industry, too, was being hit by the recession and we, and a lot of other mills, found our quality requirements being lifted as the market got tighter.

Our paper did contain pulp dirt, which of course marred its appearance. Of greater importance to us, however, was the incidence of "pickouts" from pulp dirt, notably speck or bark dirt. Pickouts occur when material is lifted from the sheet by the blanket of the offset press or the letterpress plate. Pickouts are more damaging on the offset grades because each pickout will reproduce on the succeeding prints. The pickout shows up as a hole or crater in the surface on the original sheet and as a nonprinted area on succeeding sheets, marring the printed job.

The pulp dirt causing pickouts was generally speck dirt, and usually bark. Bark specks won't bleach or bond; shive dirt will bleach to a certain extent and will bond, and about the worst they do is mar sheet appearance. This dirt was too small to be removed by our existing screening equipment consisting of conventional round and flat screens. This led to our considering additional cleaning equipment. Because of the experience some of our personnel had had with centrifugal cleaners, and because of the favorable reports being circulated throughout the industry at that time, we decided to look into this type of cleaning. We talked with the cleaner manufacturers and ended up trying in our mill six different centrifugal cleaners in a pilot plant setup on both our pulps, pine and hardwood. In evaluating these cleaners, we developed a set of considerations which we think are important in choosing a centrifugal cleaner for any mill. They are briefly:

1. Cost—how do the installation and operating costs compare.
2. Facility of operation—will the cleaners demand much operator time.
3. Safety factor—can the cleaner take care of failure of the screening equipment preceeding it.
4. Rejection rate—are the fiber losses and cost of installing and operating the various stages within your tolerance.
5. Cleanliness—will the cleaner do the job to your satisfaction.

1. The first of the considerations, cost, is pretty cut and dried and can be predetermined quite accurately with an engineering estimate of the installation. Cleaner prices are available and there are plenty of compact installation models from which piping estimates can easily be determined. Operation cost will be mainly power for pumps and depreciation with some maintenance, so these also can be determined with fair accuracy.

2. The facility of operation can and should be ascertained. Generally, a centrifugal cleaner installation is an adjunct to an existing screen room and no additional operators will be employed to run the cleaners, therefore the cleaners must be relatively free from plugging on your stock and need few operator adjustments to keep them properly running. Ideally, one of these installations needs only a glance or two per tour. This can best be determined with trial units. Set up a trial cleaner on your stock and just run it and see if adjustments are needed of if the the cleaner plugs.

3. The safety factor is something which will vary in importance with different mills.

A centrifugal cleaner is generally used to augment cleaning initiated by other equipment, i.e., round and/or flat screens. Therefore, it is often of some necessity that the centrifugal cleaner be capable of taking adequate care of a failure in this precleaning—say a hole in the flat or round screen—without

KARL DORNISH, S. D. Warren Co., Cumberland Mills, Me.

failing itself. Probable failure would be plugging of the cleaners reject oriface.

I'll give an example here. Two centrifugal cleaners did a similar job of cleaning our pine pulp. One of these cleaners was a 500 g.p.m. model, the other, 90 g.p.m. The 90 g.p.m. cleaner did show slightly better cleaning, but we chose to install the 500 g.p m. unit to forestall failure due to the large dirt inherent in our pine which would plug the smaller model should the screens fail. In other words, if we got a hold in our flat screens, the 90 g.p.m. cleaners probably would be plugged by the large dirt and accept everything coming to them. Consequences would be determined by the alertness of the operator.

4. Rejection rate is important in that a cleaner can be 100% efficient in dirt removal by rejecting 100% of the stock coming to it. Generally, the more stock rejected, the cleaner the accepted stock. The consideration here is a combination of cost and cleanliness. The cleaner should reject enough to satisfy the dirt count standards, but not reject so much that the cost of installing and operating enough stages to get a low fiber loss is excessive. You can always get clean stock if you reject enough—but at some point it isn't worth it.

For example, we tested a 20 g.p.m. cleaner in our pine and hardwood. It did a good job of cleaning, but rejected 20% of the stock entering it. We would have needed five or six stages using this cleaner to get our fiber loss down below the $^3/_4$ of 1% which we considered tolerable. This was a case where cleanliness was OK, but cost was excessive.

5. Cleanliness is of course the most important consideration. To achieve some degree of cleanliness is the purpose of installing any cleaner. In achieving cleanliness is where the particular perculiarities of pulps and cleaners come to the fore. A cleaner which does a good job on one pulp may not necessarily clean another stock satisfactorily.

I think, perhaps, the best way to discuss this point is to describe some of the things we ran into in testing cleaners for dirt removal. A little background on the project is appropriate. We surveyed our then existing stock cleaning and determined that small bark dirt was not removed (removal efficiency was about 30% for both pine and hardwood). Bark dirt doesn't bleach particularly well nor does it bond. It was the villain which caused a good part of our "pickout" troubles. Pickouts in fine printing paper are irritating to the printer and, if bad, can be extremely costly.

In determining cleaner efficiency, we developed a method of our own which suited our purposes. We sampled feed, accepted, and rejected stock; made 53-lb. basis weight samples containing 50 sq. in. of area. We used the TAPPI dirt estimation chart for our counts, illuminating the sheets by placing them on frosted glass plate marked off in 2-in. squares and illuminated from below. We called small dirt that from 0.05 to 0.02 sq. mm. Large dirt was from 0.2-sq. mm and larger. We classified also between speck and shive. Per cent dirt removal was measured in each class of dirt (small and large speck, small and large shive) by subtracting the dirt contained in the accepted stock from that in the feed stock and dividing this figure by the amount of dirt in the feed stock.

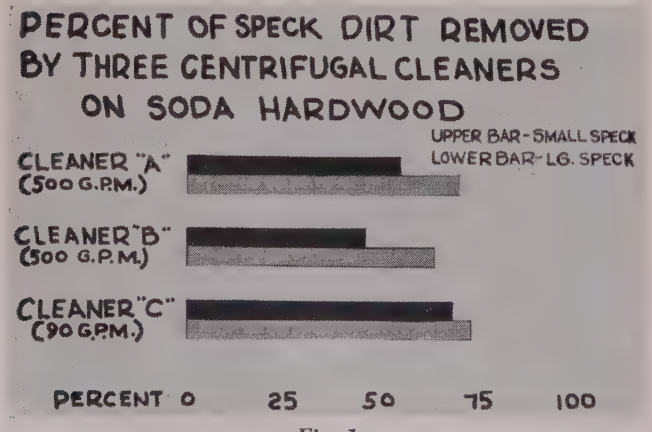

PERCENT OF SPECK DIRT REMOVED BY THREE CENTRIFUGAL CLEANERS ON SODA HARDWOOD
UPPER BAR - SMALL SPECK
LOWER BAR - LG. SPECK
CLEANER "A" (500 G.P.M.)
CLEANER "B" (500 G.P.M.)
CLEANER "C" (90 G.P.M.)
PERCENT 0 25 50 75 100

Fig. 1

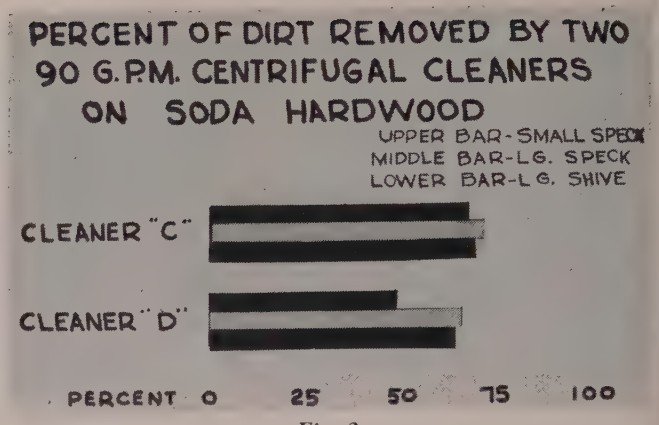

PERCENT OF DIRT REMOVED BY TWO 90 G.P.M. CENTRIFUGAL CLEANERS ON SODA HARDWOOD
UPPER BAR - SMALL SPECK
MIDDLE BAR - LG. SPECK
LOWER BAR - LG. SHIVE
CLEANER "C"
CLEANER "D"
PERCENT 0 25 50 75 100

Fig. 2

Figure 1 shows a comparison of three cleaners on our hardwood soda pulp. You will note that the top bar is small speck removal which we considered most important, and the lower large speck removal. Large shive removal was pretty similar for all cleaners tested. We did not worry about the small shives as they bleached out readily. All cleaners were operated as the manufacturers recommended.

I might interject here that we decided to install our centrifugal cleaners on brown stock on both pulps for two reasons. One, it was the place where we had most adequate thickening; and two, we figured on saving some bleaching costs by getting rid of bleach consuming dirt.

Getting back to the slide, all three cleaners did a good job in removing large speck dirt. The smaller cleaner, however, was considerably better on the small speck dirt, which as I mentioned before was our biggest problem. Consequently, the data show cleaner C to be a better cleaner on our soda hardwood than cleaners A and B. Cleaner C did the best job on the type of dirt which we considered important.

We did get into a situation which gave us food for thought in our cleaner testing. Figure 2 shows the dirt removed by two 90 g.p.m. cleaners. The upper bar shows small speck, the middle large speck, and the lower bar, large shive. The removal percentages clearly show cleaner C to be superior to cleaner D, especially with small speck. Figure 3, however, shows the concentration of large dirt in the reject sheets of the same two cleaners. The concentration is the number of large speck and large shive in the reject sheets divided by the amount of like dirt in the feed sheets. The figures are corrected for difference in rejection rate. Cleaner D showed a dirtier reject sheet, while cleaner C showed a cleaner accepted sheet. We didn't accept these data at first, but after repeated re-runs, we still came up with figures which corrobo-

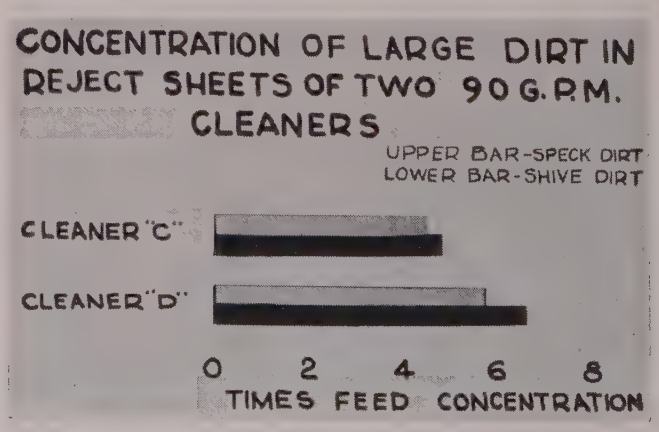

CONCENTRATION OF LARGE DIRT IN REJECT SHEETS OF TWO 90 G.P.M. CLEANERS
UPPER BAR - SPECK DIRT
LOWER BAR - SHIVE DIRT
CLEANER "C"
CLEANER "D"
0 2 4 6 8
TIMES FEED CONCENTRATION

Fig. 3

rated the first data. We then theorized that attrition occurred within the cleaner which broke the larger dirt down so that it was, one, too small to be counted as small dirt in the accepted sheets and, two, too small to be counted as large dirt in the reject sheets. We ended up choosing cleaner C for our hardwood installation.

In conclusion, these five considerations of cost, ease of operation, the safety factor, rejection rate, and, of course, cleanliness are valid and applicable in any mill. The importance of any of these in choosing a cleaner will vary with the mill and stock to be cleaned.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held in Portland, Me., Oct. 23, 1959.

New England

On Friday evening, December 11, New England Section of TAPPI continued to break all time attendance records when over 150 Tappimen jammed the Storrowtown Tavern, Eastern Exposition Grounds, West Springfield, Mass., on "Past Chairman's Night." Just 2 months ago at the Berkshire Inn, Great Barrington, Mass., the joint meeting of Conn. Valley PIMA and New England Section of TAPPI broke all attendance figures by 121—some 413 people attending.

During the afternoon Robert F. Barber, manager, Pulp & Paper Sales, The Foxboro Co., spoke on "Recent Advancements in Instrumentation for the Paper & Paperboard Industry." He was assisted by John R. Lavigne and Dana Hambleton.

Mr. Barber described the manner in which today's instrumentation is developed in a mill and the trend toward a complete engineering job by the instrument company, including training of operators.

Some trends as described by Mr. Barber are:

(1) Field mounted pneumatic transmissions being accepted by mills. These instruments simplify the entire job, including installation, operation, etc.

(2) Building centralized control panels in a centralized control room—all instruments enclosed within a central glassed in panel, away from dirt, fumes, vibrations, etc.

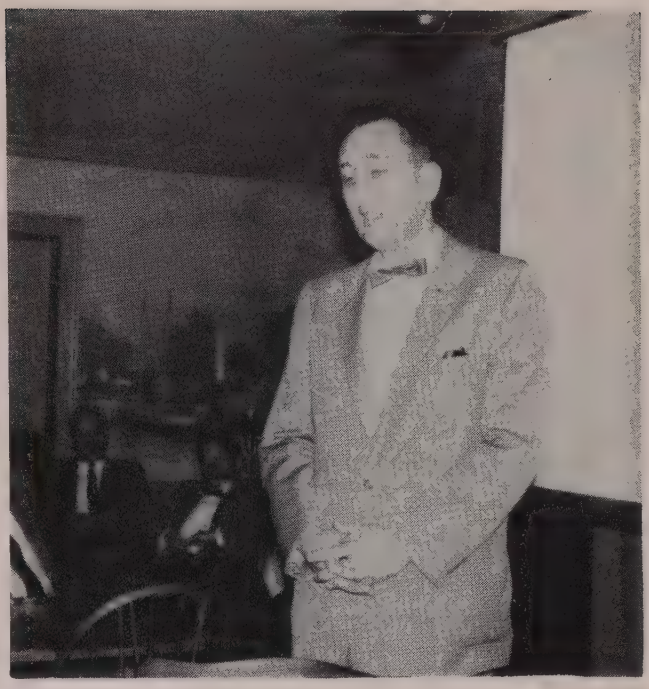
(3) Increased use of miniature instruments, small, yet compact and highly efficient, offering standardization and ease of maintenance. Miniature instruments manufactured by The Foxboro Co. were on display.

(4) The time factor as related to the installation of instrument systems was described as critical. Installation must be done as quickly as possible.

(5) Electronic Instrumentation with a.c. or d.c. signal is definitely the trend (despite only a few installations thus far) although pneumatic transmission and control still dominate instrumentaion.

(6) Computors will eventually play an important roll in instrumentation, but it will be some years before they will be installed. It was revealed that Foxboro has sales agreements with other electronic companies dealing with electronic computor systems for future use in mills.

Chairman, New England Section, TAPPI, John Lewis, Lowell Technological Institute, greets 150 Tappimen at "Past Chairman's Night"



Robert F. Barber, The Foxboro Co., who spoke on "Recent Advancements in Instrumentation for the Paper & Paperboard Industry"

(7) New polymeasurement instruments making measurements much quicker on polyethylene paper (a rapidly expanding area of papermaking) are being developed under lab conditions.

(8) The magnetic flowmeter was described as being "one real advancement in the paper field." Until 1954, when the instrument was developed, technicians had never been able to really measure flow on a maintenance free basis. With this volumetric measurement papermakers can automatically blend stocks, additives and dyes, etc. Measurement is strictly fundamentally linear with flow or velocity.

(9) An electronic recorder to measure pH was described, the trend being to constantly simplify pH measurement.

(10) Control of moisture on the machine and the methods not being used to control it were described in detail Measurement methods reviewed included: pilot drier, resistance, temperature difference, capacitance, relative humidity, and tension.

(11) The much talked about flush mount type of level transmitter was shown. This device can be used on any stored liquid, high density tower, etc., and has numerous applications.

The speaker concluded with descriptions of basis weight profilers, calipers, etc. He showed a series of slides highlighting: stock blending panels, meters measuring flow through refiners, Foxboro Magnetic Flowmeter in stock preparation areas, a complete new control system set up by Foxboro recently in a specialty mill (which was of great interest, especially to this New England audience).

After the banquet Helen U. Kiely, technical consultant, Americal Writing Paper Corp., and secretary for the New England Section for some 20 years, introduced fromer New England Section chairmen. Prior to this Miss Kiely gave a most interesting and humorous history of New England papermaking and personalities during the past 30 years.

Following is a list of past New England Section chairmen: Ned Clark, 1933–35; Roger Griffin, 1935–37; John Calkin, 1937–38; Randall H. Daughty, Fitchburg Paper Co., 1939–41; Norman I. Bearse, Oxford Paper Co., Inc., 1941–43;

David P. Habib, Technical Director, Technifax Corp., moderates technical program

William, "Bill" "Mr. Mullen -ester" Foote, B. F. Perkins & Sons (retired) 1943–45; L. B. "Tommy" Tucker, Crane & Co., Inc., 1945–47; C. H. "Chet" Child, Merrimac Paper Co., Inc., 1947–49; P. S. "Phil" Bolton, Robert Gair Div., Continental Can Co. (retired) 1949–50; R. J. Proctor, Bauer Brothers Co., 1950–51; Harold W. Knudson, Hollingsworth & Vose Co., 1951–53; Fritz Klein, Bryon Weston Co., 1953–55; Gordon L. Benson, St. Regis Paper Co., 1955–56; C. L. "Larry" Reece, Westfield River Paper Co., 1956–57; E. Whitman, "Whit," Strecker, Esleeck Mfg. Co., 1957–59; Professor John Lewis, Lowell Technological Institute, 1959–.

Of the 15 past chairmen three are deceased: Messrs. Clark, Griffin, and Calkin. Six past chairmen were able to attend the meeting, Messrs. Tucker, Daughty, Bolton, Klein, Reece, and Strecker.

Chairman John Lewis introduced the evening speaker, Phil Bolton, Robert Gair Div., Continental Can Co. (retired) who spoke on "Some Impressions of Europe, Especially Russia."

Using colored slides Mr. Bolton described his recent tour through Europe, including parts of Soviet Union. Of particular interest to papermakers was his visit to a Russian insulating paper mill using unbleached sulfite pulps. It was amusing to see pictures of the entire yard crew made up entirely of Russian women. The mill had four machines, rebuilt with Scandinavian equipment after World War II. Again, showing the emphasis on women, the best machine tenders in the mill were said to be women.

When querried by a *Paper Mill News* reporter, Mr. Bolton stated that he wasn't able to see anything unusual in the way of equipment, etc., in the mill and felt that this mill, in particular, was quite similar to those in the United States, with nothing revolutionary.

The Russian papermakers, said Mr. Bolton, were extremely friendly, exhibiting a great interest in our methods of producing pulp and paper. An official of this mill asked Mr. Bolton to bring greetings from the papermakers of Russia to the U. S. papermakers.

JOHN F. O'BRIEN, *Publicity Chairman*

Eleventh Coating Conference Sponsored by TAPPI

Edgewater Beach Hotel, Chicago, Ill.
May 23–25, 1960

Empire State (Northern District)

Left to right: J. L. Hudson, Jr., A. J. Felton, and C. B. Blanchard at the Empire State (Northern District) Section meeting

Theory and Mechanics of Conical versus Disk Refiner

A. J. Felton

MY SUBJECT tonight is "refining"—so broad in scope and so misconceived that rarely will two papermakers agree on a single method to obtain the end result.

Refining is the process of preparing wood pulp fibers so that a sheet of paper can be produced that has the desired characteristics required by the end use. Without proper planning in this area of your papermaking plant the sheet may be soft and pliable, may be dense and brittle, or may be so porous that it may not be suitable for the converting process to produce the ultimate product.

The refining system should be studied from three angles: (1) the end product and specific sheet requirements, (2) limitations of paper machine, and (3) the production goals:

First, the end product should be studied relative to maximum and minimum physical tests in mullen, tensile, tear, fold, or crush.

Second, the paper machine should be studied to assure the sheet desired can be produced, with proper formation, surface characteristics, strength properties, and desired tonnage.

Third, the production goal should be studied to provide information on furnish required, electrical potential and water availability.

Any bottleneck in these areas will have a definite throttling effect on production and indirectly on company operating profits.

Any sound refining plan should include a look at what you have accomplished and how the existing system compares to the ultimate system required. This assures proper planning so that existing equipment will be utilized wherever possible. It, too, points to the weaknesses of the existing refining engines and gives an indication of capacities and limitations.

All refining performance should be gaged by the end objective! For any given sheet production and furnish there are two or more methods to achieve the end result. The universal yardstick that points the way is horsepower-per-ton-per-day. The numerical value may vary slightly, but you will find that those schooled in refining-system planning will agree within very narrow limits.

Having established the desired power input either from historical data, or objective concept, the next step is the selection of the refining engine. Too often theories are accepted

A. J. FELTON, Executive Sales Engineer, Black-Clawson Co., Shartle Div., Middletown, Ohio.

without logical reasoning: for instance, some people believe that a head scratcher is a "deep thinker"—more than likely he has itchy dandruff—or—that a fellow who gets up and pulls up his trousers is a "go-getter" type—probably he doesn't want to be embarrassed by having his pants fall down.

So examine the refining engine for design, manufacturers' claims, and logical explanation of refining action.

There are two basic continuous refining engines: one, the conical type and, two, the disk type. We have not overlooked the Hollander or finishing beater but its use is so limited in modern refining systems that we consider it usable only in rag stock preparation.

The conical type and the disk refiner were conceived approximately at the same time—in 1850. However, proper metals, bearings, and precision machining were not obtainable and the disk refiner was shelved. The conical type, however, was developed and introduced into the pulp and paper field and advanced to present-day design by technological study of results and effect.

Information as to speed, horsepower, and bar structure while available, was not technically applied until the late 1940's and early 1950's. This came about by the influx of technically trained men from respective paper colleges who no longer were willing to accept the old, but raised the question of "why."

Recent studies have indicated a relationship between the relative amount of hydration and cutting and the contact pressure between bars of the refiner filling. The relative amounts that can be obtained from a particular refiner are dependent upon relative speed of the filling, bar-to-bar contact area, and stock consistency.

This ratio of hydration can be changed by:

1. A change in refiner speed. This will either increase or decrease the backed off (or no load) power. This will allow either less or more loading horsepower. The higher the horsepower available for loading the higher the unit pressure between bar surfaces and consequently the more relative cutting that will take place. Thus for a given drive motor size, the faster the speed, the less cutting is done mainly because of a decrease in loading factor.

2. A change of bar-to-bar contact area. If, in a given refiner, the number of bars is increased without decreasing the bar width, the bar-to-bar area will have increased. For a given thrust there will be less unit pressure and hence less cutting. If, on the other hand, the bar width is reduced without increasing the number of bars there will be less contact area and more cutting.

3. Stock consistency. This is a matter of viscosity and concentration of stock particles. A heavier consistency has a higher viscosity whereby the backed off (no load) power is absorbed as turbulence, mechanical working of the fibers is due to resistance to shear. The difference between refining at $2^1/_2$ versus 5% is mainly that at 5%, twice as much stock is present in a given volume with the result that there is more contact between stock fibers, much less isolation from the water. This same effect would be present in a Hydrapulper operating at 5 instead of $2^1/_2$%.

The loading factor referred to above may be calculated for any particular refiner under a particular set of operating conditions. This allows a predetermination of the type of treatment on other engines with different speeds and/or fillings.

The calculation of this loading factor is as follows:

Area_1 = small end area, sq. in.
Area_2 = large end area, sq. in.
Area_3 = projected area, sq. in. $(A_2 - A_1)$
F_1 = thrust against small area, lb.
F_2 = thrust against large area, lb.
F_3 = thrust against projected area, lb.
P_1 = stock inlet pressure, p.s.i.
P_2 = stock outlet pressure, p.s.i.

Force
$F_1 = P_1 \times A_1$
$F_2 = P_2 \times A_2$
$F_3 = \frac{P_2 - P_1}{2} \times A_3$ (approx.)
$\Sigma F = F_1 + F_3 - F_2$
Σ = summation force

(negative result equals inward thrust)

ΣF is the net thrust due to the stock pressure difference only. To this must be added or subtracted the thrust exerted by the handwheel. This new net thrust is equal to the force exerted for refining. In a disk refiner this is the thrust exerted on the filling faces while in a jordan this force must be corrected for the angle of the filling. There is a mechanical advantage (inconical refiner) as the normal force on the bars themselves is the above net thrust divided by the sine of one half the included angle. This new thrust is the normal force exerted over the gross area of the truncated cone which must be corrected by a factor for each type and size of filling combination.

The resultant in pounds per square inch is now a true contact pressure between bar surfaces.

The disk refiner was introduced into grain defibering and grinding fields where precision machining was not required. The disk refiner as applied to papermaking had been periodically tried but did not reach any great degree of success until bearing design and proper materials became available. This was deemed necessary to give controlled adjustable clearances between the disks.

Let us examine the basic reasoning behind each of the two designs.

The conical refiner was designed to adjust for bar structure wear by moving a conical plug into a mating shell. It usually has rather wide bearing centers, has a small deflection due to heavy plug and seeks its own rotating center when rotating in a mass of stock which acts as a lubricating medium around the rotating member. The design permits vernier or minute adjustment for clearance.

Experience has taught us that a narrow bar at slow speed, $^1/_4$ or $^3/_{16}$ in. thick at 2000 to 2700 f.p.m. large-end-periphery in 2 to $3^1/_2$% consistency will give excellent fiber length reduction. This will impart to the finished sheet good burst formamation, and give drainage rate control. Wide bar at high speed $^1/_2$ or $^7/_8$ in. thick at 5000 to 6000 f.p.m. large end periphery in 4 to 6% consistency at reasonable bar pressure will not give large drop in freeness, nor reduce fiber length to any great degree. This enhances tear and fold and improves clay coating retention.

There is a strong suspicion that extra wide bars (as in a bidwell liner) at the lower speed of 2000 to 2700 f.p.m. large-end-periphery will yield as much hydration at a power savings. There is some indication that some mills are now using this idea successfully. This is obviously an advantage for, as we mentioned previously, the real yardstick is horsepower per ton per day.

Bar material also plays an important part in the effect of any conical refiner. Stainless steel type 431 is the best hydrating material because the leading edges round off and the material work hardens when operated in the hydrating range. Chrome-moly-nickel alloy is next and phosphor bronze is third. In the fiber length reduction engine phosphor bronze is best because it wears rapidly and normal to cutting edge and remains razor sharp. CMN alloy is second and stainless steel third.

Consistency also plays an important part in the effect of any refiner. Two to $3^1/_2$% is best cutting range since the fibers will tend to mat over the leading bar edge so that the fibers are in the shear area. The bar structure is in close intimacy and shear loads are experienced on all fibrages on bars.

At 4 to 6% the stock is so dense that the fibers mat around the rotating member so that bar-to-bar contact is not possible and rubbing or hydrating action results.

In the conical type refiner there are wide, deep spaces between the plug bars that contain a large quantity of stock that does not receive the full effect of the bar structure due to (1) path through the unit, (2) the high pumping effect of the angled plug, and (3) the limited circulation of the refined stock.

There is only a small force to return the stock into refining zone once it has been impelled into shell bar structure. With new fillings having deep grooves circulation is less than when filling becomes worn. The pressure within the unit is dependent on the inlet pressure plus the pressure head produced by the plug as a booster pump.

At a given intimacy or bar-to-bar clearance gallonage falls off from a maximum when filling is new to a point of replacement at which time the gallonage is so low production can no longer be maintained. This is true of both conical and disk machines.

The basic design of the disk refiner was considered to provide the entire refining job in a single pass. No provision was made for independent hydration or cutting action. The theory was to design the bar structure so that more physical contact would be obtained for any given volume of stock and greater fibrillation at a higher freeness. This would result in stronger sheet properties. It was reasoned that a narrow shallow groove, multiple bar disk would do this.

The design comprises flat surface disks, overhung, to allow very short bearing centers and a small amount of self alignment on the stock cushion.

Narrow shallow grooves are intended to give positive full circulation of all stock between the disks. The disks are provided with positive pressure setting (this means clearance between the disks) by external hydraulic system. The pumping effect is controlled by disk design and gap, and is inversely proportional to the disk clearance.

The disks are so designed and operated that within a certain range the flow rate can be controlled. This is commonly referred to as "pump through" or "hold back."

It has been the desire of disk refiner designers to produce pulp that resembles standard beater pulp with light jordaning treatment rather than the standard jordan-type stock.

Disk design studies reveal that when disks are machined with stationary bar and rotating bar parallel to one another upon impact—high noise level—heavy cutting results. When rotating bars are machined at right angle to stationary bar on contact no impact area exists and the unit refines by turbulence and attrition. This type of treatment gives high mullen to tear ratio, high horsepower absorption, and very low capacity per unit. It would appear that the final design should be somewhere between these two extremes.

In the disk refiner the cubic amount of fiber available for refining is considerably less than in a comparable size conical refiner. The disk refiner depends on the nip between the disks, the bar pressure and disk design for a type of treatment that gives higher ratio-of-fiber treated per-pound-passed than a comparable conical refiner which depends on fibrage mat over advancing bar edge and, which is only a small percentage of that fiber available in the deep grooves.

Normally, disk refiners operate at approximately four fiber diameter clearance and can pump high consistency stock. Unfortunately, when soft and hard fibers are in the furnish, the hard fibers tend to pinch off and shorten the soft ones. Often the soft fibers are long and impart desirable characteristics to the sheet. This is the cardinal reason why stocks of different strengths should be refined separately and blended at the stuff box.

You may have wondered why a 36-in. diam. disk refiner with a gross refining area of 1330 sq. in. has the same size drive motor as a conical jordan with perhaps 3000 sq. in. gross area. The difference between the ratio of bar area to gross areas are such that the actual working bar areas are very much the same.

The disk refiners are well suited to parallel operation. It is possible to retain extreme fiber length and good beating qualities in several units, combine this stock with stock from a disk refiner set up in cutting position, and have a finished sheet that retains not only bulk—but density.

Recent developments in disk design leads us to believe that a bar structure can be developed that will give not only standard hydrating effect but jordan effect as well.

My experience with refining engines has convinced me that they are capable of developing pulp strengths that the paper machine cannot translate into comparable web strengths. This apparent failure can be attributed to headbox, slice, shake, table roll action, length of pond, and apron.

Many paper strength tests have included a machine factor. This comprises the tests from headbox stock, formed into handsheets, run through TAPPI series, and compared to dry-end sheet samples put through comparable tests. There have been instances recorded of machine effectiveness as low as 50%. We have instances where primary stock after refiners has 120% burst, with secondary headbox stock at 130% burst and the machine formed sheet recording only 105.

This is not a normal occurrence, but does demonstrate that laboratory tests should not be accepted *per se*, but only indicative of the trend possible with the pulp—though not obtainable with the paper machine. The question always arises "which refining method is the most efficient and which is properly applied where?" In an effort to shed some light on this important subject we examined data from 125 paper machines where a comparison could be drawn for disk refining, disk-conical refiner treatment, and all conical refiner treatment.

The following data are presented as a record of existing facts and with no intention of an over-all comparison between refiner installation. It is recognized that there are many factors not taken into consideration such as, pulp quality, wood species, type of cook, refiner speeds and tackle, and machine speeds which would effect over-all power consumption and performance of the installation for the specific board and paper produced. The data are presented merely to show the over-all difference in refining power consumption which is the common denominator for evaluation.

It is intended for academic interest only and we suggest that direct comparison with your own operations take into account many other factors which bear a proper relationship.

In the production of 42-lb. linerboard in 12 Southern mills we found this variance between refiner design systems:

	Hp./t/d Primary stock	*Hp./t/d Secondary stock*	*Variance of primary stock*
Disk refiner	6.7	15.0	...
Disk-conical refiner	7.7	13.8	14.9%
Conical refiner	8.4	17.6	25.2%

All machines produced a minimum of 500 tons daily and no distinction was allowed for geographic location. All mills used coastal woods. It is very significant to note here that a great majority of papermakers contributing to this survey felt that the conical refiner applied to secondary stock provides a more uniform fiber length and freeness control.

In the production of "multiwall bag" it would appear that the opinion of the mill people is that the conical type of refiner provides the type of treatment required for this sheet.

We consider this term "multiwall" a misnomer since it is not manufactured to a single set of standards but the final test must reach a wide range of conditions that vary with the end use.

Thus the papermakers must be provided with refining tackle which through experienced manipulation enables them to meet these rigid tests.

Table I. 42 lb. Linerboard (11 machines)

Daily tons		*Hp./t/d Primary*	*Hp./t/d Secondary*
	Disk-Refiner		
700		5.5	13.0
800		6.25	18.7
475		7.01	19.0
800		7.5	15.0
850		7.3	24.2
	Average	6.7	15.0
	Disk-Conical Refiner		
600		7.5	16.4
720		6.8	13.9
750		9.0	11.3
	Average	7.7	13.8
	Conical Refiner		
750		9.7	8.7
500		9.0	19.0
500		7.2	25.2
	Average	8.4	17.6

Here the "art" of papermaking is exemplified since they are able to secure desired combinations of cutting and hydrating treatment in a single machine.

In the production of 9-pt. we did not observe a machine with disk refiner system.

It should be noted that in this survey we examined two machines located in the same mill side by side of equal width and operating speeds—one with disk-conical refiner system and the other with conical refiner only. The variance in favor of the disk-conical system was $16^2/_3\%$.

In the production of foodboard we observed most of the machines being operated on high tonnages where particular emphasis is placed on the production of half gallon bottom stock and 60 and 75-lb. cupstock. Only one system employed disk refiners but its product was limited to bottlestock. Therefore, it is impossible to show a comparison of variances on the power consumption basis, and Table IV is included to explain the basic facts of life regarding the choice or type of refining systems to manufacture food board.

In the production of publication papers, the information is recorded in Table V.

Table II. Multiwall Bag (23 machines)

Daily tons		*Hp./t/d*	*Variance*
	Disk Refiner		
273		8.35	
200		12.5	
500		9.0	
212		19.8	
	Average	12.4	...
	Disk-Conical Refiner		
350		9.45	−24%
	Conical Refiner		
300		10.0	
330		10.87	
300		19.5	
336		12.5	
230		16.7	
225		20.0	
240		8.75	
200		8.75	
120		16.6	
	Average	14.9	+20%

Table III. Nine-point (11 machines)

Daily tons		*Hp./t/d*	*Variance*
	Disk-Conical Refiner		
200		18.0	
410		9.05	
175		30.5	
	Average	19.18	...
	Conical Refiner		
200		21.0	
500		10.18	
530		7.55	
400		15.4	
55		19.1	
410		9.05	
100		14.25	
100		12.75	
	Average	13.66	−25.3%

In numerous other systems:

9	installations	—cigarette, bible, offset
2	"	—kraft gumming
4	"	—multiwall wrapping
5	"	—cotton filter
10	"	—twisting and toilet tissue
3	"	—facial tissue
3	"	—saturating sheets
16	"	—folding grades (boxboard)
6	"	—magazine

we found conical refiners exclusively.

The pattern of application of the basic types of refiners appears to be very closely related to the ultimate physical characteristics required in the paper or board products being manufactured. Conversely, the raw material and the methods of refining available in any specific mill determines the type of end product.

On the basis of actual field installation data, it is observed that both types of refiners have definite applications to obtain optimum operating economy and strength development characteristics of the raw materials to meet the end product specification. For example, note that conical refiners are indicated for the production of paper products requiring specific "printability" characteristics.

Additional detailed studies of actual operating experiences coupled with current developments of both the disk and conical types of refiner, will surely shed further light on the art of papermaking and the mechanics of equipment engineering. Certainly, although we wish it were true there seems to be no single refining engine that will act as a panacea to meet all the requirements of the papermaker.

MILLS OF THE FUTURE

It has been observed from the data presented here from tests in southern mills that the disk refiner is more efficient from a power input standpoint than a comparable size conical refiner on some pulp fibers where lignin and other impurities are incrusted on the surface of the pure cellulose.

On high-speed kraft machines it has been found that production records have been broken by the disk refiner

Table IV. Foodboard (9 machines)

	Conical Refiner	
330		9.7
315		4.92
400		9.0
220		3.2
170		7.65
200		17.5
190		12.15
93		16.8
90		15.0
	Average	10.7

Table V. Publication

Daily tons	*Hp./d/t*	*Variance*
	Disk-Conical Refiner	
	20.0	
	20.0	
	19.1	
	27.4	
Average	22.2	...
	Conical Refiner	
	5.4	
	9.0	
Average	7.2	−67½%

arrangement because the bursting strength curve plotted against freeness shows higher burst at much higher freeness thus allowing faster water removal.

If we can apply this advantage to mill design of the future it is entirely conceivable that two separate disk designs will be used in southern kraft mills. One to produce the long well beaten fiber and the other to produce the fines to fill the surface interstices so that the stocks will blend together into a sheet that will meet not only the bulk and density requirements but burst, tensile, and tear as well.

In the folding grades field perhaps a higher freeness stock will be used on cylinder machines. The same freeness differential may exist between the liner and filler vats but the base freeness will be somewhat higher due to the special type of refining treatment possible with disk refiners. This treatment gives excellent defibering and good fibrillation at higher freeness and may permit increased production at higher machine speeds.

It is conceivable that disk refiners will become an important adjunct to cylinder board mills and that a combination disk and conical-type system will produce better quality at less cost.

Others may believe as we do since we found experimentation with disk refiners going on in two magazine mills, two patent coated linerboard mills, one cotton-linter filter mill, and two gypsum board mills. Results up to this time are not conclusive but certainly should prove interesting.

In closing, the immediate future should result in great strides being made in stock preparation. To our knowledge there are several concurrent developments being made to the equipment itself but perhaps of greater importance and certainly of immediate interest to you is the fact that never before in the history of papermaking have there been so many qualified equipment suppliers available to paper mills who can come in and at your convenience help you analyze, much as we have done here tonight, the future course to be taken in the improvement of your respective grades.

Presented at the meeting of the Northern District of the Empire State Section of TAPPI, held in Watertown, N. Y., Dec. 10, 1959.

Ohio

H. C. Brill of E. I. du Pont de Nemours & Co. addressed 173 Ohio Tappimen on "The Retention of Titanium Dioxide in Paper" at a dinner meeting at the Manchester Hotel, Middletown, Ohio, Dec. 8, 1959.

Dr. Brill's presentation showed a nice balance of practical with theoretical considerations drawn from some 15 years of extensive experience with titanium pigments. He pointed out that titanium retention is largely due to agglomeration and mechanical filtration. He stated that the optimum particle size for optical properties is such that sufficient positive charge per unit of particle weight to produce good retention by electrostatic attraction cannot be imparted.

Dr. Brill then went on to discuss the various methods of controlling agglomerate size, such as amount and concentration of the reactants; presence and amounts of dispersants such as starch; degree of agitation; time elapsed between pigment agglomeration and paper formation, and temperature.

Dr. Brill then went on to discuss the various methods of controlling agglomerate size, such as amount and concentration of the reactants; presence and amounts of dispersants such as starch; degree of agitation; time elapsed between pigment agglomeration and paper formation, and temperature.

Following the talk, Robert P. Green of The Champion Paper and Fibre Co., program committeeman for the meeting, presided over a lengthy question-and-answer period.

George E. Martin, *Recording Secretary*

January

The January meeting of the Ohio Section of TAPPI was held Jan. 12, 1960, at the Manchester Hotel in Middletown, Ohio. There were 133 members present for the meeting.

The meeting was called to order by the chairman, Virgil E. Perry. Mr. Perry made the announcement of the February meeting.

After these preliminary announcements the meeting was turned over to Ray Essex of the Howard Paper Co. Mr. Essex then introduced the speaker for the evening, Julius H. Mappus, Jr., of West Virginia Pulp and Paper Co. Mr. Mappus is at the present time supervisor of control laboratory and Clupak Paper Development.

Mr. Mappus gave a very interesting talk concerning the development of Clupak.

He described to the group the manner in which the process was developed from a basic patent by Sanford L. Cluett, inventor of the sanforizing process.

Briefly, the Clupak process utilizes the elastic properties of rubber to mechanically compact fibers on the paper machine. As the paper web passes through the drier section of the machine, it is brought in contact with rubber in a stretched condition. This rubber contracts and compacts the fibers, resulting in a paper with high stretch and the surface characteristics of regular paper.

This built-in stretch increases the strength of the sheet (tensile energy absorption) by three to five times. At present this paper is being used in making kraft multiwall sacks, where strength is the primary consideration of the package.

At the conclusion of the talk there was a very interesting question-and-answer period. The meeting was then adjourned.

George Martin, *Recording Secretary*

Pacific

Pacific Section of TAPPI held its third meeting of the year in Longview, Wash., Jan. 19, 1960, at the Monticello Hotel. This was an engineering meeting and was moderated by B. W. Gibson, Chief Design Engineer of the Longview Fibre Co.

The program starting at 2:00 p.m. saw four papers given and with extensive discussion periods after each paper, the meeting lasted till after 5:00 p.m. The following papers were presented:

1. "Engineering Evaluation No. 3 Paper Machine Rebuild," by George Robertson, Simpson Paper Co., Everett, Wash.
2. "Size Press Starch Control," by Jack Decker, Columbia River Paper Mills, Vancouver, Wash.
3. "Temperature Controlled Spent Sulfite Liquor Diversion System," by E. A. Woodworth, Crown Zellerbach Corp., West Linn, Ore.
4. "Black-Clawson (Pandia) Continuous Digester Operation at Potlatch Forests, Inc., Lewiston, Idaho, Mill," by Robert Linkhart and Tom Tudder, Potlatch Forests Inc., Lewiston, Idaho.

Following the technical program, a social hour at 6:00 p.m. permitted everyone to get acquainted. Dinner was served

B. W. Gibson, Longview Fibre Co.

at 7:00 p.m. and was highlighted by color slides of the British Columbia back country shown by guest speaker M. H. A. Glover, director, Bureau of Economics and Statistics, Department of Industrial Development, Trade and Commerce, Parliament Buildings, Victoria, B. C. It is interesting to note that mill personnel in attendance totaled 94 out of a total attendance of 123 present.

ROBERT SMYTHE, *Secretary-Treasurer*

Number 3 Machine Rebuild

G. C. Robertson

THE original no. 3 fine paper machine producing book, offset, label, and writing grades was installed in 1926, it was of P&J manufacture being capable of a maximum mechanical speed of 600 f.p.m. The owners of the mill at that time being the Everett Pulp & Paper Co. at Everett, Wash.

In 1951, the mill was acquired by Simpson Timber Co. and due to the over-all condition of the machine a minor rebuild was made during 1951. The main changes at that time included the installation of a Valley headbox, additional driers in the first drier section and a new winder.

The first major rebuild to no. 3 machine was in 1952, the major change being to increase the maximum mechanical speed of the machine from 600 to 750 f.p.m. This change necessitated a corresponding increase in the machines drying capacity and miscellaneous auxiliary equipment.

The planning for our most recent over-all rebuild was started in 1956. It was then decided that in order to meet the ever increasing demands for greater production and higher quality a more extensive rebuild would be necessary for no. 3 machine if these demands were to be met.

The complete project was planned and the general design work accomplished by Simpson's combined production and engineering staffs. They include Mel Olson, resident engineer and his senior project engineer John Gould, W. A. McKenzie, former resident engineer and now general manager of Simpson's Engineered Wood Products Co., H. R. Russell, paper mill superintendent, and F. R. Hamilton, director of research and product development.

The general design work and detailed engineering was

G. C. ROBERTSON, Simpson Paper Co., Division of Simpson Lee Paper Co., Everett, Wash.

George Robertson (left), Simpson Paper Co., and Robert Linkhart, Potlatch Forests, Inc.

handled by H. A. Simons Ltd. of Vancouver, B. C., engaged as consulting engineers for the complete project. The general contractor on the project was H. S. Wright Co. of Seattle who completely removed the old machine including soleplates and erected the new machine in a record time of 47 days.

Before discussing the new machine further I would like to briefly outline the drier sections and associated equipment of the old machine so that a comparison can be made between the old and the rebuilt machine. This comparison, relative to the drying capacity, was used in the over-all evaluation of our Ross totally enclosed hood.

The old machine which had three drier sections had a total of thirty-one–60-in. diam. paper driers and five–48-in. diam. felt driers resulting in a total drying surface of approximately 6420 sq. ft. The machine also had an open type hood over each drier section, a bottom felt hot air system supplying the first two drier sections, and one Ross Grewin Unit supplying air to all sections.

The new machine which we have named "The Royal Chinook" is of Beloit Iron Works manufacture with a few old machine parts re-used and has a 155-in. wide with a 105 ft. 8 in. long fourdrinier wire. The pressure headbox is designed for a maximum speed of 1200 f.p.m. and the differential line shaft drive for a maximum mechanical speed of 1500 f.p.m. The machine proper incorporates the latest design features applicable to machines manufacturing similar grades of fine paper as we do at Simpson. A short description of several of these features will be discussed shortly, together with a brief outline of the problems which we have experienced since the start-up of the machine in late November, 1958.

The drier sections of the new machine have a total of forty-eight–60-in. diam. paper driers and 12 felt driers, three of which are 48 in. diam. and nine 60 in. diam. The resulting drying surface being approximately 70% greater than the original machine. The machine has a Ross totally enclosed hood on the first two drier sections and an open-type hood on the after drier section. It was also necessary to increase the capacity of the bottom felt hot air system and install an additional Grewin unit to provide the necessary air for the increased number of drier rolls.

With reference to the wet end of the machine, it has been our experience that the portion of the flow from the fan pump to the Beloit pressure headbox is extremely important, relative to the performance of the headbox proper. Therefore, I would like to follow through briefly the flow from the tray

water silo up to the headbox in an effort to help clarify my following comments on this section of the rebuild.

The stainless steel tray water silo which is located on the drive side of the machine is 6 ft. in diam. and extends from approximately 2 ft. below the elevation of the fourdrinier wire to the basement floor. It has a conical shaped bottom, fitted with a tea-type connection, one leg of which is piped upwards to the machine stuffbox, the other leg being directly connected to the suction of the fan pump. I may also mention that the automatic basis weight control valve, which is an 8-in. DeZurik plug type, is located on the gravity drop leg from the stuffbox to the silo discharge tee, the valve proper being controlled from the headbox control panel.

The fan pump has a maximum capacity of 7300 g.p.m. at 170 ft. head and is, as previously mentioned, directly connected to the bottom of the tray water silo. From the fan pump discharge, the flow is upwards into the primary Bauer cleaner header, the cleaners being mounted on the back wall of the machine room behind the headbox. We have a bank of 15 no. 623 Bauer cleaners the rejects being discharged into a vacuum reject system which is designed to prevent the cleaners from drawing in air at the reject tips. The accepted stock from the Bauer cleaners discharges into a common header which has four top outlets, the lines being connected to four Black Clawson selectifiers mounted on a mezzanine floor approximately 15 ft. above the operating floor. I may also mention that we have found that three of these selectifiers are capable of screening more than the maximum volume of stock required on the machine at any time, the fourth selectifier being used as a standby. The selectifiers are also fitted with automatic reject valves, the timing cycle being controlled from a control panel on the operating floor.

We come now to the section of the stock flow which has caused us appreciable trouble, that is the flow from the selectifiers to the Beloit pressure headbox.

The flow from the selectifier outlet header is downwards to a 12-in. Beloit stream flow valve which is located on the front side of the machine behind the headbox. On the downcomer line to the stream flow valve a 10-in. by-pass line is taken off which connects into a Bustle ring around the bottom of the tray water silo. Installed on this line are two DeZurik control valves, one of which is a 6-in. manual loaded valve, the other being an 8-in. automatic control valve. The function of the 8-in. valve is to maintain a constant pressure directly ahead of the stream flow valve regardless of any increase or decrease of water on the machine brought about by opening or closing the stream flow valve. The 6-in. manual loaded valve being used when necessary to bring the control valve into range.

By maintaining this constant pressure, we are then able to hold the velocity of the stock constant at the recommended design figure. However, due to several design points and the fact that we produce a large number of different grades and have relatively short runs, the machine operators frequently control the amount of water to the machine by using the 6-in. manual loaded valve only. This in a sense defeats the original purpose of the valve. However, we have found that we are still able to maintain a fairly constant pressure on the stream flow valve as long as no changes are made to the Bauer Cleaner pressures, etc.

During the first few months of operation when we were at lower speeds the headbox proper gave us, in general, no severe problems although we had the usual operational problems which were anticipated due to machine operators being unfamiliar with a pressure-type headbox and new equipment. However, in due course the problems were corrected with the help of Beloit field engineers. I should really correct my last statement appertaining to the performance of the headbox as the problems that have existed since the rebuild were not all minor ones. In general, we have had at various times experienced poor formation, formation streaks, profile variation, and general streaking which were all initially pinpointed on the headbox proper.

However, we have during the past few months made several small adjustments to the fourdrinier including the shake units which decidely helped the formation and formation streaks in general. The general streaking from the headbox, profile variation, and headbox level fluctuation are still, however, causing us problems.

Several months ago Beloit Iron Works, after evaluating various headbox installations, concluded from their tests that a stock flow of 20 to 22 ft. per sec. was more desirable, performance wise, in the headbox inlet header than a flow of 7 to 10 ft. per sec. which was the velocity that our original inlet header was designed to achieve. We, therefore, decided after consideration of all the factors that we would replace our original header with a new one, designed to increase the velocity to the higher figure. The new header is of a tapered design, the stock entering through the end of the header at the front side of the machine. The stock discharges into the throat of the headbox through thirty 2-in. diam. pipes equally spaced along the width of the headbox. This arrangement also provides a more uniform flow from the header to the headbox proper, as well as the higher flow velocity. Beloit Iron Works have also determined through further tests that the pressure of the stock in the headbox inlet pipes should be equal over the width of the headbox. This is partially accomplished by the design of the header proper, the final equalization being accomplished by installing a recirculation line from the back end of the inlet header to the Bustle ring on the tray water silo. Installed in this recirculation line is a manual loaded control valve by which the machine operators can balance out the inlet header pressures; the differential pressure being read from a gage mounted adjacent to the control valve manual loader on the headbox control panel. It may also be of interest to state that the recirculation line is theoretically designed to pass approximately 20% of the flow through the stream flow valve, when the recirculation valve is in the open position.

The new header and recirculation line was installed on the machine at the end of December and since that time we have been able to observe the resulting effects on the machine proper. The results obtained, as yet, have in some respects fallen short of the performance change anticipated and we are still trying minor adjustments to help the situation. However, a partial evaluation can be made at this time as the changeover has, we feel, eliminated several of the problems that have existed since the rebuild.

The first problem I will discuss pertains to the general streaking of the stock from the headbox out onto the wire. This condition has definitely been improved since we installed the new header, Beloit's theory being that the original header which had a small number of large diameter inlet pipes tended, depending on the headbox throat opening, to allow the stock to channel through the box instead of being uniformly distributed over the entire width of the headbox.

Since we installed the header we have also tried various throat openings on the headbox and have made general changes to the position of the slice and slice rectifier roll in an effort to obtain the best performance. During the first two weeks we experienced formation problems on our light grades, the formation actually being worse than before the header changeover. This was finally traced back to the headbox throat opening, which we had to reduce to increase the velocity of the stock and give better distribution. However, in general, regarding formation we do not feel that the new header has contributed in any way toward achieving still better over-all sheet formation.

Profilewise, we believe that we have benefited slightly by the header change and by slice adjustment improved our original profile by 10%. We believe, however, that in time we will be able to reduce the variations even further.

The headbox fluctuations are still a problem which we have yet to solve. We have found that at the lower speeds of approximately 800 f.p.m. the level holds relatively steady. However, above this speed the fluctuations increase both in magnitude and frequency, the magnitude ranging from $^1/_2$ to a $1^1/_2$-in. water. Therefore, we feel that the new header has not helped dampen the fluctuations and are at present once more checking out the stock flows, etc., in an effort to pinpoint the elusive source of trouble.

We have found that the major improvement which can be directly attributed to the header changeover is improved uniformity across the reel, regardless of type of formation.

In summation on the headbox proper, we at Simpson believe that although the new type header has not proved a cureall, it was definitely a worth-while change, this statement being based on actual results and an important step in the right direction.

We refer now to the drying sections of the machine which have a total of forty-eight–60-in. diam. paper driers and 12 felt driers. These driers are divided up into three sections. The number of driers in each section are as follows: 1st section, 22 paper, driers, 2 felt return driers and 4 Feeny felt driers; 2nd section, 13 paper driers, 2 felt return driers and 2 Feeny felt return driers, and the after driers section which has 13 paper driers and 2 felt return driers.

The Ross totally enclosed hoods, which are installed over the first two drier sections only, are of the latest design. It is fabricated from double sheets of corrugated aluminum having a 3-in. thickness of glass wool insulation which very effectively reduces the heat radiation. The top portions of the hoods are similar to conventional-type open hoods with the exception that an inner plenum chamber is added. This chamber extends the full length of the hood on the drive side of the machine. The air being exhausted from the hood is drawn into the plenum chamber through a narrow opening extending the full length of the chamber on the approximate center line of the machine.

We have four air exhaust fans for the three hoods, these fans being located on a mezzanine floor above the machine differential drives. Two of these exhaust fans handle the air requirements for the first drier section enclosed hood, each fan having a design capacity of 27,000 c.f.m. The design capacity of the single exhaust fans on the 2nd drier section and the after-drier section is 22,000 c.f.m. and 45,000 c.f.m. respectively. It can therefore be seen from these figures that the open type hood on the after-drier section requires approximately twice the volume of air to carry away the water evaporated from the sheet than the 2nd drier section, each having the same number of driers. From tests the approximate moisture pick-up per pound of dry air has been determined for each section and are as follows: 1st and 2nd drier sections 0.1 lb. water vapor per lb. of dry air, the 3rd drier section 0.05 lb. water vapor per lb. of dry air.

The major portion of the air required to properly absorb the water vapors and convey them to atmosphere is delivered to the driers through the basement felt supply system. This air must be heated from outside conditions to a relatively high temperature. Therefore, since the total air requirements for enclosed hoods are approximately 50% less than an open-type hood, steam usage at these sections is reduced.

The prefabricated aluminum front and back panels of the enclosed hoods are designed to give as airtight an enclosure as practicable. This prevents leakage of moisture laden air into the machine room. The lower panels on the drive side of the machine, which are 8 ft. high, slide sideways to provide adequate access to the driers. The lower panels on the front side of the machine slide upwards by motor-driven windless arrangements, the drives being mounted on a walkway on top of the hood. These panels can be raised or lowered in sections by push button control affording entrance to any individual section. In the event of a break in the web all the front panels rise automatically in unison and remain in the raised position until the appropriate push button is pressed.

The machine operators, in general, are completely satisfied with the enclosed-type hood. When the tending side panels are lifted the side of the machine is entirely clear of obstructions giving them complete access to the driers.

The working conditions in the machine room proper have also been improved, the insulated enclosure preventing the radiation of heat and diffusion of vapour into the working areas.

The main advantage costwise, primarily accomplished by the installation of the enclosed hoods, has been the reduction in steam per ton of paper off the machine; our steam cost having been reduced by approximately 10%.

A partial study pertaining to the estimated improved moisture control with enclosed hoods was made several months ago. However, the tests we made are still incomplete, therefore no comments will be made on this subject.

It may, however, be of interest to mention while we are on the subject of moisture control, that we have two Honeywell moisture graphs installed on the machine. These units read the electrical resistance of the sheet by direct contact of a 4-in. diam. steel roller against the sheet proper, as it passes over a drier roll. This electrical resistance being a direct relationship of the percentage moisture in the sheet.

One of these units is installed on the last top drier of the 2nd drier section and automatically controls the steam pressure in this section. This is accomplished by manually positioning the set point of the moisture graph to suit the moisture content required. Any deviation from this setting repositions the set point of the steam pressure controller, thus maintaining a relatively uniform moisture content in the sheet ahead of the size press.

The second moisture graph is installed at the dry end of the machine, the steel rollers running on the reel drum. This unit is a recorder only, its function being to enable the back tender to immediately notice any change in the required moisture content at the reel.

We are entirely satisfied with the performance of these units, and they have definitely assisted us in maintaining a more uniform sheet, moisturewise, at the reel.

Referring again to the rebuild in general, I would like to briefly discuss two important benefits which were realized by modifying and improving our existing flotation saveall. On the original machine the clarified white water from the saveall was pumped back to our white water storage tank. We are now using this water directly back to several of our fourdrinier showers, thus effecting a considerable savings in fresh water. This was to us extremely important since our fresh water supply is limited.

The saveall modification also resulted in receiving a relatively constant volume of recovered solids from off the saveall. Instead of pumping these solids to the broke storage chests, which we did prior to the rebuild, we now pump it directly to a mud box located above the machine tray water silo. The solids from the mud box flow by gravity into the bussle ring on the bottom of the silo, an overflow being provided in the box proper to maintain a relatively constant flow. We have found that by adding the solids at this point along with retention aids we obtain better retention on the fourdrinier wire, have better stock formation, and have realized savings in titanium and clay.

As a final point of interest, the machine is provided with a broke system consisting of one machine width Lieback pulper manufactured by E. D. Jones. The pulper is designed for continuous extraction and is installed in the basement directly under the second calender stack and reel. It is provided with completely automatic consistency and level controllers operated from a control panel on the dry end of the machine operating floor. The slush broke from the pulper is pumped to a broke storage take-up tank which has an approximate capac-

ity of 5000 lb. of 4½% stock. We then pump the stock automatically on level control from this tank through a small Jones refiner, then to our broke storage chests.

In conclusion, the modernization rebuild of the Royal Chinook has been quite satisfactory though as with any new paper machine there are a myriad of problems to work out. We have made and still are making many adjustments, and feel that we now have one of the best fine paper machines in the country.

Presented at the meeting of the Pacific Section of TAPPI, held in Longview, Wash., Jan. 19, 1960.

Southeastern

A meeting of the Southeastern Section of TAPPI was held at the King and Prince Hotel, St. Simons Island, Ga., on Nov. 20–21, 1959. Mr. Chase, Section chairman, called to the attention of the whole membership the problem of the social meeting in the yearly schedule. By a show of hands, the membership indicated their interest in continuing the practice of the last meeting; i.e., substituting social/sports events for a mill visit.

S. N. Cooper, assistant woods division manager, Brunswick Pulp and Paper Co., greeted the group and welcomed them. A tour of the Brunswick mill was conducted on Saturday morning.

Determination of Yield in Neutral Sulfite Pulping

J. D. Robertson

The proposed method for the determination of yield is based on the theory that yield is a function of the per cent soluble solids in the total moisture-free product of the digestion of the wood. The moisture-free product consists of fiber and soluble solids. The soluble solids consist of solubilized organic material from the wood and soluble inorganic material from the pulping chemicals in the white liquor. The proposed method for yield determination naturally assumes a knowledge of the chemical to wood ratio and the analysis of the white liquor in terms of sodium sulfite and sodium bicarbonate.

Examination of the reactions that occur during neutral sulfite pulping will give a general idea of the composition of the soluble solids portion of the digestion product. It may be assumed that the material removed from the wood during the digestion will appear in the digestion product as soluble organic solids. This fraction will embrace such substances as lignin, in the form of sodium lignosulfonate, wood acids combined as sodium salts, sugars, and soluble gums, along with a small fraction of miscellaneous extraneous substances. The sodium bicarbonate, during the process of digestion with the wood, will lose water and carbon dioxide and appear in the soluble solids fraction of the digestion product as its equivalent of Na_2O. The sodium sulfite in the white liquor will appear in the soluble portion of the digestion product unchanged. This is true, whether it adds to the lignin as such, or first reacts with wood acids to form salts and sodium bisulfite, the latter compound adding to the lignin. In either case, no loss from the sodium sulfite is indicated. As to demethoxylation, it may be commented that the ether linkage is very strong. Demethoxylation, if it occurs, is a minor reaction and may be disregarded in the over-all material balance.

A procedure can now be outlined for the determination of yield in a neutral sulfite digestion. A representative sample of the total product of the digestion is collected, including both cooked chips and occluded liquor and spent liquor outside the chips in an equivalent quantity. Collection of a representative sample will be relatively simple in a continuous process. In the batch process, a close approximation of a representative sample can be arrived at by volumetrically sampling both the cooked chips and the spent liquor outside the chips.

Triplicate aliquots of the combined representative sample are dried to constant weights in an oven at 130°C. The average of the resulting weights is designated W.

Triplicate aliquots are then disintegrated in a Waring Blendor in hot water. Pads of pulp are formed in a Buchner funnel and thoroughly washed with hot water. The washed pads are dried to constant weight in an oven at 130°C. The average of these weights is the fiber in the aliquots, and is designated F.

Then:

(1) $\frac{W - F}{W} \times 100 = Y$ = Per cent soluble in the moisture-free digestion product.

Let

X = per cent yield.
Y = per cent soluble in the moisture-free digestion product.
C = per cent chemical ($Na_2O + Na_2SO_3$) based on moisture-free wood.

The calculation is based on one mass unit of wood. Therefore:

(2) $1 - \frac{X}{100}$ or $\frac{100 - X}{100}$ = mass of organic soluble in the product.

(3) $\frac{C}{100}$ = mass of the inorganic soluble in the product.

(4) Adding (2) and (3):

$\frac{100 - X + C}{100}$ = mass of the total soluble in the product.

(5) $1 + \frac{C}{100}$ or $\frac{100 + C}{100}$ = mass of total moisture-free product.

(6) Dividing (4) by (5) and multiplying by 100:

$$Y = \frac{100 - X + C}{100 + C} \times 100$$

(7) Transposing equation (6):

$$X = \frac{(100 + C)(100 - Y)}{100}$$

This equation has been tested on known data obtained in 12 determinations of per cent soluble solids in the total digestion product of typical neutral sulfite cooks. In this case C, the per cent $Na_2SO_3 + Na_2O$ in the white liquor, based on moisture-free wood, was 8.82. The equation for this series of determinations then becomes:

$$X = \frac{108.82\,(100 - Y)}{100}$$

Applying this equation to the figures for Y found in column II, the figures for yield in column III were obtained. Each datum in the table represents the average of four digestions.

I	*II*	*III*
Month, 1956	*% Soluble in dry product, % Y*	*Yield, % X*
Jan.	26.7	79.77
Feb.	28.7	77.62
March	26.3	80.21
March	28.0	78.35
April	26.8	79.66
May	25.1	81.51
July	25.0	81.61
Aug.	23.7	83.03
Aug.	26.1	80.42
Oct.	28.2	78.13
Nov.	26.2	80.29
Nov.	28.4	77.92
Average	26.7	79.77
Standard deviation		1.31
Coefficient of variation		1.64%
Yield, %, inventory method		79.0

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Average yield is 79.77%, as determined by the foregoing method. A comparable yield, determined by the inventory method, was 79.0%. The accuracy of the proposed method is sufficient for routine yield determinations.

SUMMARY

A relatively simple method for the determination of yield in neutral sulfite pulping has been proposed. This method is both rapid and accurate, as attested by the results of 12 actual determinations covering 48 batch neutral sulfite digestions. Many of the inaccuracies inherent in the inventory method of determination are avoided. The determination of yield as a function of the soluble fraction of the total digestion product is submitted for your approval and your use as a routine control method.

Presented at the meeting of the Southeastern Section of TAPPI, held at St. Simons Island, Ga., Nov. 20, 1959.

Atmospheric Improvement Activities of the Pulp Industry

E. R. Hendrickson

Probably each of you at one time or another have received complaints about odors from your mill operations. In the immediate vicinity of mills, objections are frequently raised about the effects of fallout from recovery furnaces, lime kilns, and bark burners. Vegetation damage has been attributed to fallout and sulfur dioxide. Damage to structural materials and painted surfaces has been reported from airborne saltcake particles and various sulfur-containing gases. A few of you have been involved in litigation alleging paint blackening from hydrogen sulfide. All of these are effects attributable to materials which may be discharged into the air from pulping operations. In short, all may be due to air pollution from pulp mills.

Air pollution is popularly defined as "excessive concentrations of contaminants in the air recognized by people because of the undesirable effect on people, the things people own, and the things people like to do." Among the most important effects that people recognize are: (1) visibility interference, (2) sky darkening, (3) soiling of surfaces and materials, (4) annoyance to senses, (5) damage to vegetation, (6) other property damage, (7) interference with production or services, and it is rather difficult to discuss air pollution in generalized terms because of the many facets involved. Despite the difficulties, however, the problems of air pollution must not only be discussed, but must be understood because of the rapid development of serious public interest in the subject. During the legislative year of 1957 more than 20 states considered some form of legislation against air pollution. Approximately 12 states have passed restrictive legislation to date. Numerous communities, including counties and cities, already have restrictive ordinances in effect. At the present time, except for a few instances, the pulp and paper industry has not been singled-out as an industry involved in gross pollution. A few instances are on record, however, where individual members of the industry have been involved in law suits claiming paint damage, detrimental health effects, and odors. Since present conditions may not continue indefinitely, it behooves individual mills to take an interest in the materials they are discharging into the air. This interest must be extended to the point of keeping records of weather conditions and airborne discharges. For this reason, the National Council for Stream Improvement has established several research projects for investigation of air pollution problems which might be faced by the industry. It is fortunate that the industry has this foresighted program since agitation for air pollution control activities has been moving far more rapidly than similar activities in water pollution control. Research in stream pollution was carried out 50 years before specific restrictive regulations became popular. In the pulp industry, pollution research was started at least 20 years prior to the introduction of this type of law. This has not been true in air pollution legislation. Here, unfortunately, research is progressing hand in hand with many control activities. It is also unfortunate that much of our research must be directed toward finding a solution to immediate problems rather than taking a forward look at long-range problems. From my personal experience with air pollution control activities, control agencies look with considerably more favor on industries having a planned program of attack on their air pollution problems and a research program in existence *before* they encounter serious trouble.

It would possibly be of some help to discuss the effects of possible air pollution from sulfate pulping and describe some of the solutions which are being used or under consideration. In discussing the possible solutions, I would like to describe some of the activities on the existing research projects as well as mill activities observed during a recent tour of a number of mills.

Among the effects which might be considered are fallout, health, hazards, odors, and paint damage. These are not the only observed difficulties, but are probably among those more frequently observed. They are not listed in any order of importance, but merely as they came to mind. Fallout, of course, may be in the form of saltcake, flyash, soot, burned bark and wood particles, and lime. Some of these actually do damage to materials, vegetation, and painted surfaces. Others merely contribute to the general dirtiness of the surrounding area. The larger particles, of course, fall out close to the source, but smaller particles may be carried several miles. Those which remain suspended in the air contribute to visibility interference, sky darkening, interference with transportation services, and may help to carry odors long distances.

Health hazards from concentrations of gases discharged from sulfate pulping operations are not considered to be of serious consequence. Of the compounds which might be involved, the toxicity of sulfur dioxide and hydrogen sulfide are well known, but little is known of the true air pollution signatures of sulfate pulping, mercaptans, dimethyl sulfide, and dimethyl disulfide. The only data obtained so far from Sweden indicate that hydrogen sulfide is about ten times as toxic to rats as disulfide and mercaptan. From purely circumstantial evidence and observation along many lines, it has been tentatively concluded that toxic gases are not as sufficient concentration around pulping operations to justify air pollution control on the basis of health hazards. If, on the other hand, we accept WHO's definition of health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity," we might include the odors involved as detrimental to human health. No disease or infirmity has been proved to be directly caused by odors *per se*.

Odors in the vicinity of pulping operations are considered obnoxious by many individuals. As such they might be held to constitute a nuisance. If a recent court decision starts a trend in this direction, the encroachment of odors on private property would be considered trespassing. It is known that under appropriate weather conditions, which are not present all the time, the odor from sulfate pulping operations may be noticeable many miles away.

Paint damage has been attributed to saltcake fallout and discoloration by hydrogen sulfide. The latter is probably the most common complaint around sources of this gas. Recent investigation by the paint industry has thrown some additional light on the blackening effects of hydrogen sulfide. It might be well to point out that many master painters, paint salesmen, and a few paint manufacturers still hold that a lead pigmented paint is necessary for the best outdoor coatings. This belief of long standing may not be valid in the light of numerous weathering tests of fume-resistant paint. Most

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fume-resistant paint contains titanium oxide as the main pigment but all of the best outdoor paints contain some quantity of lead pigments to improve weathering. Conclusions reached in the study by the paint industry included the following:

1. With hydrogen sulfide present in the atmosphere, no blackening occurred unless the paint contained lead pigments.
2. The degree of blackening varies directly with the lead metal content.
3. Regardless of the humidity of the atmosphere, little blackening occurs unless the paint surface is actually wet with water.
4. Small concentrations of hydrogen sulfide will produce blackening under optimum conditions at slower rates than high concentrations.
5. Blackening is considerably delayed if the paint film is glossy and unweathered.

Solutions to some of the problems of air pollution facing the industry are not easily forthcoming. Research on the projects inaugurated at universities and research institutes and at individual mills is slowly producing results. Two projects are sponsored by the National Council for Stream Improvement at the University of Florida and at Washington State. The objectives of these two projects were originally aimed at immediate investigation of control activities through a multiple approach. It was soon found, however, that one of the first needs was adequate and accurate sampling methods and the original objective thus had to be postponed while sampling was investigated. Up to the present time, the University of Florida project has studied problems of the effects of meteorology on the dispersion of air pollutants. This has been reported in an Atmospheric Pollution Technical Bulletin of the National Council for Stream Improvement. Simplified techniques have been developed for aerial sampling. These are available in the form of a technical bulletin. Stack sampling procedures have been developed for the recovery furnace stack and these results will be available shortly. At the Washington State project, development has proceeded along the line of instrumentation for aerial surveys and investigation of gas chromatography as a tool for odor analysis. This work has been reported in the Technical Bulletins of the National Council for Stream Improvement.

Shortly after the air pollution project at the University of Florida was activated, an attempt was made to determine the concentration of gases of interest which might result from sulfate pulping operations. The literature was searched and individual mills contacted. This investigation revealed a dearth of reliable information. The data which were available were characterized by numerous instances of contradiction. It was not immediately apprent whether this was due to process variables or a lack of reliable sampling techniques. Statements from many of you, however, gave strong evidence of a weakness in the latter.

At that time it was evident that it was becoming increasingly important for a mill to know what materials were being discharged into the air, and what was happening to those materials. It is important for each mill, for its own protection, to maintain reasonable records concerning the weather and possible damaging compounds in its emissions. Atmospheric Pollution Technical Bulletin No. 1 was prepared by our laboratory and published by the National Council for Stream Improvement in September, 1957. The bulletin contained a critical review of the literature on procedures and analytical methods of value in determining compounds of interest from sulfate pulping operations. Many of these methods resulted from extended studies by well-qualified investigators. Separation and analysis of many of the contaminants of interest is extremely difficult because the compounds are very reactive and some are easily oxidized. None of the available techniques were found to be completely suitable for air pollution investigations. Many are quite involved, requiring a considerable amount of expensive equipment and extensive technical knowledge on the part of the sampling personnel.

In cooperation with some of the southern mills, a plan of attack was formulated. It was decided that new techniques were necessary which would be specifically applicable to air pollution investigations, but which would provide valuable data for other uses. It was further decided that it was unnecessary to determine the concentration of all the compounds which might result in air pollution problems but merely to investigate general classes of materials.

Further conferences with operating personnel as well as others experienced in air pollution investigations developed the relative sequence of sampling locations which would be investigated. The initial work was started in the area of stack sampling with the recovery furnace being the first target. It was felt that this was the largest single source of discharge of materials which might pollute the air. The outlet side of any control device was selected as the point of sampling. It was felt desirable to use as many standard items of equipment and as many standard techniques as possible. To provide adequate information while keeping the determinations as simple as possible, it was decided to sample for particulates, sulfur dioxide, hydrogen sulfide, and total sulfur as sulfur dioxide. By this procedure other reduced sulfur compounds could be determined by difference. The investigation program was in line with the philosophy of our laboratory to obtain that information which is necessary at the least cost consistent wtih providing reliable data.

Samples are withdrawn from the stack through a stainless steel sampling probe and filter holder. The rate is 0.3 c.f.m. The thimble holder remains inside the duct during sampling and does not, therefore, have to be heated. Leaving the ducts, stainless steel or Pyrex glass tubing, wrapped with a heating tape to remain about 100°C., conducts the air sample to a stainless steel manifold which is also maintained above 100°C. At this point the flow is split into three equal streams and conducted through three separate sampling trains. The first train consists of three gas washing bottles in series, containing a solution which will enable the determination of sulfur dioxide. The second train consists of two gas washing bottles in series, but contains a reagent suitable for collecting hydrogen sulfide. The third stream first passes through a quartz combustion tube, maintained at approximately 1000°C. At the entrance of the tube, a small flow of pure oxygen is introduced. This converts all of the reduced sulfur compounds to sulfur dioxide which is collected in a sampling train similar to no. 1 except containing only two units. Each of the three streams are metered before connection to a second manifold and thus to a source of vacuum.

The analytical techniques used are reasonably standard. In all cases a colorimetric procedure has been adopted. The sulfur dioxide scrubbing solution is treated with *p*-rosaniline and formaldehyde, and subsequently develops a red-violet color. The intensity of the color with respect to a reagent blank is measured on a spectrophotometer and the concentration determined for a previously prepared standard curve. The hydrogen sulfide scrubbing solution is made acid to dissolve the zinc sulfide and the evolved H_2S is allowed to react with *p*-aminodimethylaniline sulfate in the presence of ferric chloride. This results in the formation of methylene blue in direct proportion to the amount of sulfide present in the solution. It is necessary that the entire reaction take place in a closed container. In the laboratory experiments conducted during the past year, none of the compounds commonly encountered in the recovery furnace off-gas were found to interfere with the analytical procedures.

Individual mill activities are more directly aimed at control. Unfortunately, many of these developments seldom are to be found in the literature. At present three general approaches are being used for reducing odors and reducing fallout from recovery-furnace particulates. To improve the effectiveness of salt cake recovery, secondary scrubbers have been installed in some instances following primary collection devices such as electrostatic precipitators. These take several forms al-

though most are commercially available devices. One of several which I have recently observed is a device originally intended for air cooling by water sprays. Apparently good contact is made between solid and liquid particles and the solid particles reduced considerably in concentration. Unfortunately, the mist collection device on this apparatus appears inadequate and some mist containing sodium salts in solution escapes. Because of a change in particle size, the problem area has changed in location. A mist collector of improved design could improve the situation. The second unit is also a water contactor making use of the venturi principle. A series of venturi sections through a bulkhead intercepts the air flow with a spray nozzle mounted directly in front of the venturi throat. The discharge from the throat impinges against the flat section of the following bulkhead thus collecting much of the water spray. Following discharge from the unit, a tall stack is used as a mist collector. This unit is reported operating in a satisfactory manner.

To assist in odor reduction, a number of mills in the northwest are installing or operating black liquor oxidation units. The theory is that oxidizing the sulfur compounds in the liquid before evaporation and burning will prevent the formation of many of the odorous compounds which are now released. These units take three general forms; packed towers, thin film oxidation, and aeration by porous plates. Except in those cases where pine is pulped, no foam problem is encountered. As one progresses eastward across the country, more and more severe foam problems are found until they reach their peak in the pine pulped in the southeast. At present black liquor oxidation is under observation at the National Council for Stream Improvement's regional laboratory in Baton Rouge. This study is aimed specifically at the application of black liquor oxidation to southern pulping conditions.

Another approach to odor control being used or considered in more and more mills is the collection and oxidation of blow gases and digester vent gases. The most satisfactory way of collection appears to be removal of the condensable fractions, followed by storage in a floating-cover gas holder or a diaphragm-type gas holder. The gas holder floats on the line to take care of the surges induced during a blow. Oxidation of the collected gases has been accomplished by burning and by mixing with bleach plant effluent. Burning has been accomplished in a separate furnace and in the lime kiln. Precautions must be taken to prevent flash-back and subsequent disaster. This is accomplished through the use of flame traps, blow out panels, a gas velocity higher than the flame propagation rate, and thorough mixing with excess air before introduction into the burner.

This paper has offered but a brief description of some of the problems encountered by pulp mills in the South, and some of the research activities directed toward solving these problems. Further research into many of the problems of air pollution which potentially face the pulp industry is urgently needed. Some of the investigative work can best be accomplished at individual mills. Other problems should represent a group effort and be logically handled by the existing research projects established at Universities and Research Institutes. Speaking for the Air Pollution Research Laboratory at the University of Florida, we solicit your suggestions and recommendations and in turn offer our assistance in your air pollution problems to the limit of our resources.

Presented at a meeting of Southeastern Section of TAPPI, held at Brunswick, Ga., Nov., 20, 1959.

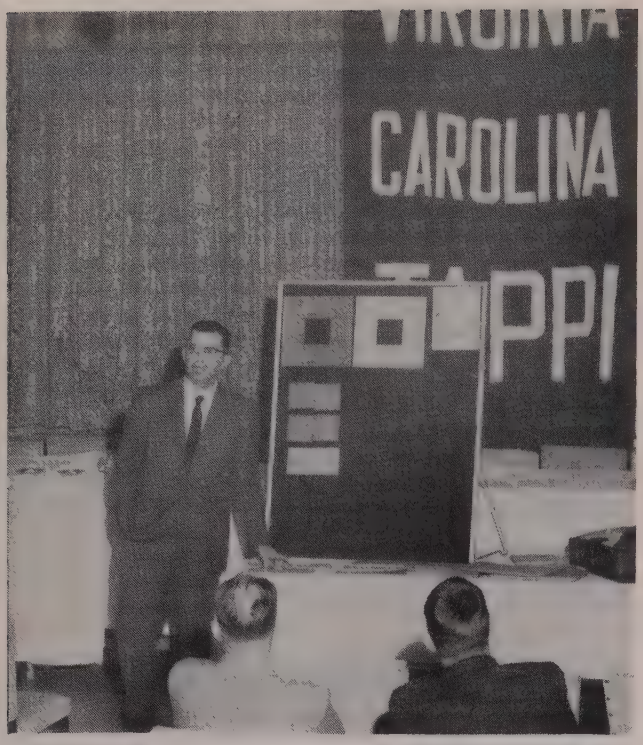
Virginia-Carolina

The December 4 meeting of the Virginia-Carolina Section of TAPPI was held at the John Marshall Hotel in Richmond and was attended by 65 members. The first paper presented was

The executive committee of the Virginia-Carolina Section of TAPPI. Left to right: R. F. Traver, R. B. Hobbs, R. H. Simmons, R. F. Miller, Garland Edmonds, K. D. Running, C. E. Snook, R. G. Hitchings, G. S. Bailey

View of dinner meeting on the roof-garden of Hotel John Marshall, Richmond, Va.

From left to right: R. F. Traver, Union Bag-Camp Paper Corp.; S. J. Ryczak, Chesapeake Corp.; Ross Miller, Continental Can; G. H. McGinnis, Union Bag-Camp Paper Corp.; H. D. Jurgenson, North Carolina Pulp Co.; R. G. Hitchings, North Carolina State College



G. H. McGinnis, Union Bag-Camp Paper Corp., Savannah, Ga.

by Stanley Ryczak, pulp mill superintendent of Chesapeake Corp., West Point, Va. The second paper presented was evaporator de-misting by H. D. Jurgenson, chief chemist pulp mill of North Carolina Pulp Co., Plymouth, N. C. This paper was also presented at the recent Alkaline Pulping Conference. However, additional data were obtained which indicated that the efficiency of de-misting increased directly with the velocity of gases in the evaporator. At relatively low velocities the mesh separators seem to have little advantage, whereas at high velocities the separators had a very marked benefit. A third paper was presented by R. G. Hitchings, associate professor of Pulp and Paper Technology, North Carolina State College. This paper was entitled, "Program Progress at North Carolina State College." Mr. Hitchings' talk was accompanied with a number of slides which illustrated the physical facilities of the college—showing classroom and laboratory facilities and commercial equipment available for use by students and by industry.

Mr. Hitchings' paper ended the afternoon section of this meeting. The meeting of the Executive Committee was then held and after a brief social hour, dinner was served. George H. McGinnis of the Savannah bag factory of Union Bag-Camp Paper Corp. was the after-dinner speaker. His subject was "Printing on Kraft Paper," with particular attention to the effect of various backgrounds on the color effect obtained. A flannel board presentation was used to considerable effect to illustrate his points, resulting in a very stimulating talk.

The next meeting of the Virginia-Carolina Section will be held at the John Marshall Hotel on March 18. The afternoon session will begin with registration starting at 1:00 p.m. and the technical program beginning at 2:00 p.m. A very interesting program is expected, and all interested personnel in the pulp and paper field are invited to attend.

Tall Oil—A Batch System

Stanley Ryczak

THE term tall oil comes from the Swedish word, "tall," meaning pine. Translated into English we would have pine oil. However, a product by that name was already in existence here in the United States. Hence, the name tall oil was retained.

STANLEY RYCZAK, Pulp Mill Superintendent, Chesapeake Corp. of Virginia West Point, Va.

Tall oil is a natural mixture of oils obtained from pine wood used in the kraft, or sulfate, process of pulp production. These oils are mainly derivatives of rosin acids related to abietic acid and fatty acids related to oleic acid. As a result of being products formed in an alkaline process, containing sodium salts, they occur as sodium soaps of these acids and must be processed into crude tall oil.

Tall oil has been made in this country for years before the second World War; the volume was small compared to present day production. It was during the second World War when there occurred a shortage of fats that much research and development took place in the United States concerning this relatively unknown material. This increased interest in tall oil has expanded the fields in which its constituents could be used to such an extent that it has become economically attractive to kraft pulp mills to recover as much of this by-product as is possible.

The uses of these materials are widespread. Roughly 45% of the mixture is converted into rosin size to be used in the papermaking process. The remainder finds uses in the paint industry, printing inks, soaps and detergents, flotation agents to mention just a few of the many uses found today. Continued research will undoubtedly expand the field.

For many years before the spring of 1957, The Chesapeake Corp. sold its soap skimmings as such. In 1956 it was decided to build a crude tall oil plant to handle our present capacity and to allow for an increase in production in the future. This decision was influenced by the desires of the Hercules Powder Co. to obtain an adequate supply of crude oil for the refinery they were planning to operate at Franklin, Va. Their supply comes from several mills in the Virginia-Carolina area, and gives the supplying mills a reliable disposal of their production.

What was to be our decision? We, at Chesapeake, knew practically nothing about tall oil; it was something very new to us at the time. After visiting with some of our friends in the industry and looking over both batch and continuous plants, we were confronted with making a decision between the two. Each system was evaluated as to initial cost of installation, yields, operating labor costs, ease and flexibility of operation, maintenance costs, and quality of product.

At the time of this investigation not too much information could be had concerning the operation of continuous plants which were quite new at the time, and which were in the process of proving themselves.

Data were meager, although much was being claimed. Operational difficulties, adjustments, and changes take time to be evaluated. Of course, at present there are many very efficient and well operated continuous plants in operation. But time was a matter to be considered by us. Also, we were of the opinion that a batch plant could be made to operate much more efficiently in view of the fact that little had been done to improve them over the years.

Another question concerned operating manpower. In a continuous process an operator is required 24 hr. a day; this means three or four men, depending on the shift schedule. In a batch process, it is possible to operate one 8-hr. shift per day, five days a week, if the cook tank is sized properly, and, if adequate storage of skimmings is provided. A sizable increase in production would add only one more man for a second shift. This difference in manpower is significant over a year's time with wages and fringe benefits as they are today, and was a factor given much consideration in making a decision as to what type of plant to build.

Considering the question of yields, there were no doubts that continuous plants were giving higher yields. However, there was no apparent reason why yields could not be improved in batch operations if they were set up and made to

operate under changes which would tend to improve yields. With improved operational techniques and closer attention given to procedures, oil yield and quality could both be upgraded.

The difference in initial capital investment between a batch and continuous system to fit our particular need was not very great. However, this can be something which can vary depending upon the choice of materials of construction, etc.

After careful consideration of all these factors, The Chesapeake Corp. decided to build a batch plant and the services of a consultant in this field were obtained. His job was to design a complete plant which would allow an 8-hr. day operation, five days a week to take care of present needs and still allow for some increase in productive capacity, and, as mentioned earlier, in the case of a sizable increase in pulp production, the plant could be made to operate on two shifts a day, five days a week.

The physical make-up of the plant consists of the following:

1. Two 40 ft. diam. × 24-ft. high soap storage tanks.
2. One 18 ft. diam. × 18-ft. high sulfuric acid storage tank.
3. One 18 ft. diam. × 21-ft. high spent acid storage tanks.
4. One 20 ft. 2 in. diam. × 20-ft. high cook tank. This tank is lead lined with $^5/_{32}$-in. lead, lined with a double layer of acid resistant bricks set in acid-resistant mortar, and has a stainless steel agitator and shaft.
5. Two 12 ft. diam. × 18-ft. high wet oil tanks.
6. One 36 ft. diam. × 30-ft. high oil storage tank.
7. One 8 ft. diam. × 6-ft. high caustic white liquor storage or transfer tank.
8. All necessary pumps, piping and valves to handle the various materials.

The production of tall oil can be divided into three steps, as follows: (1) soap separation from black liquor, (2) soap storage and settling with black liquor drainage, and (3) converting soap to crude tall oil.

Some of the factors affecting the yield of crude tall oil are: (1) Seasonal changes in wood, (2) length of time wood is stored before use, (3) wood species, (4) cooking conditions in digestion, (5) pulp washing efficiency, (6) soap skimmer efficiency, and (7) operational efficiency of the crude tall oil plant.

The production of tall oil has its origin in the cooking process. Pine chips are digested, or cooked, with heat and pressure with a cooking liquor consisting mainly of sodium hydroxide and sodium sulfide. This separates the cellulose from the other wood constituents. The strong caustic solution forms sodium soaps of the lignin and the resin and fatty acids. The black liquor remaining after the cooking process contains these soaps; pulp washers remove the black liquor, the black liquor is concentrated in multiple effect evaporators before being burned in a chemical recovery furnace.

During the evaporation process, at a solids concentration of approximately 25%, the liquor is sent to skimmers, or soap separators. Essentially, these are simply retention tanks which are calculated to be large enough to hold the liquor in them for a sufficiently long enough time for the soap to separate, float to the top, and be collected. The liquor is then returned to the evaporators. Proper baffling of skim tanks is necessary to prevent short circuiting or channeling which greatly reduces skimmer efficiency. A means of controlling the liquor level in order to keep the liquor volume constant is desirable. Retention time should have a minimum of 50 min., longer being more desirable.

The collected soap is transferred to the large storage tanks mentioned earlier. The purpose of the large size of these tanks is to provide usage out of one for about two weeks while the other is receiving soap daily. Every day settled black liquor is returned to the evaporator feed tank from the tank being filled. This provides soap drained relatively free of black liquor. Now this point is important since the soap is not washed ahead of conversion as in a continuous system. It is important from the standpoint of economy of operation to have such large storage capacity for soap and to allow time for liquor separation and disposal. The presence of black liquor in soap is objectionable because it consumes considerable sulfuric acid and forms much lignin precipitate. Lignin is known to affect the rate of separation of the tall oil in a cook; it also causes some loss of oil for it tends to bind oil to itself if present in large amounts. Then, too, lignin removal must be considered.

Lignin removal from the cook tank is carried out once a week, the lignin itself being of some value since it is burned in the recovery units. It is dissolved in the cook tank in white liquor and water at about 220°F., and pumped to a tank from which it is added hourly in smaller amounts to the recovery unit head tank. Research being carried on today will find some uses for this strange material now being burned. Any losses of chemicals in the white liquor so used are assumed to be small since it all returns to the recovery system. Losses would most probably be in the form of sulfur gases.

A description of the cooking cycle follows: let us assume a batch has just been completed, which normally occurs shortly before noon. The cook is then allowed to stand and separate into layers, there being three. The top is tall oil, the middle lignin, the bottom spent acid. After 2 to 3 hr. is allowed for this to take place, syphoning of the tall oil layer is carried out and as much tall oil is transferred to the wet oil tank as is practical on the same day the cook is made. One of the most important reasons for removing the tall oil from the cook tank so soon is that if allowed to stay overnight there, a degradation of the oil actually occurs at the high temperature of 210 to 200°F. and the oil becomes darker in color. This has been shown by analysis of samples taken immediately after completion of a batch and samples taken 20 hr. later in the cook tank before transfer. Similar analysis of samples immediately after completing a cook, and 4 hr. later after transfer to wet oil storage showed the acid number to drop but slightly.

Some of the tests on samples of oil allowed to stay 20 hr. in the cook tank dropped as much as five in acid number value. Transfer to wet oil storage drops the temperature about 30 to 40°F. and slows down this degradation and formation of neutrals. After this operation, the batch stands till the next morning when the operator again skims off as much oil as is practical and adds it to that of the previous day. The operator intentionally tries not to skim very closely until the last day before a clean out cycle. Skimming too closely will tend to transfer some lignin to the wet oil tank.

The wet oil tank allows about 4 hr. for further settling of any spent acid and lignin that may be present in the oil transferred. After that time, it is pumped to a large storage tank which contains a heater automatically controlled to hold the temperature at about 170 to 180°F.

Once a week the bottom of the wet oil tank is pumped back to the cook tank to recover the settled spent acid and lignin, if any. Our experience has been that very little lignin carries over and this is due largely to close operator supervision of the skimming operation which he controls.

After the oil skimming operation, the next step is to remove some of the spent acid, or salt cake solution, from the cook tank. This is put into a storage tank for subsequent transfer to the recovery system. On a clean-out day, all the spent acid is pumped out to storage. At this point the original cycle called for lignin removal each day and recharging the tank with spent acid. We have changed this procedure and make either four or five batches a week, cleaning out once a week without difficulty and without any large loss of tall oil being bound to the lignin. Once a week the bottom of the spent acid storage tank is returned to the cook tank to return any lignin and oil that may have been carried over. Thus far we haven't had to clean the spent acid storage tank because of the presence of lignin.

After spent acid removal, a measured volume of water is charged. The agitator is started and the desired amount of 66°Bé. sulfuric acid is added through a flowrator. The

agitator and shaft are of stainless steel and have a propeller type about half way up the shaft and a turbine type near the bottom. During the vigorous agitation after acid addition live steam is used to heat the contents to over 200°F. Following this step, the desired amount of soap skimmings is charged by a Viking gear pump. The amount of soap used is measured by a manometer calibrated in pounds of soap based upon the specific gravity of settled soap. Of course, the specific gravity varies some due to different degrees of soap settling and the varying quantities of liquor entrained. The average specific gravity checked over a few months period has been 1.008, ranging from 0.979 to 1.113. Practically speaking, these are fairly close measurements, for adjustments of pH are few and when needed are easily made.

After all the skimmings have been added, the batch is allowed to cook for at least 20 min. Then it is sampled and tested for pH by the operator using a Beckman pH meter. If the test is correct, the agitator is shut down and the cook allowed to separate into the three layers mentioned previously. If an adjustment or adjustments of pH are necessary, they are carried out and the cook agitated for at least 10 min., per adjustment, until the desired pH is obtained.

The desired pH is 4.2 to 4.3. At this point there is practically no residual soap in the tall oil, nor excess acidity to be corrosive to tanks, lines, etc. The presence of residual soap in tall oil presents foaming problems in washing at the refinery.

During the time soap is added to the hot acid solution, most of the soap is converted to tall oil very readily. The oil formed is able to hold soap dissolved in it; for this reason vigorous agitation is necessary to effect the intimate mixing of this soap with the acid in the spent acid for completion of the conversion. The reaction is rapid and soon an equilibrium condition exists at which the pH of the tall oil and spent acid solution are the same.

Vigorous agitation is beneficial for another reason. Lignin formed in a cook with vigorous agitation precipitates as fine hydrated particles which are easy to handle. Without this agitation the lignin would fuse into large, hard masses and most likely would require removal by hand. The fine particles of lignin are readily dissolved in white liquor with heat for transfer to recovery furnaces.

Tall oil transferred from the cook tank to wet oil tank contains from 1.5 to 2.0% moisture, present as dissolved and suspended water. After several hours in the wet oil tank, it is transferred to the large storage tank for further drying and shipment. Actually, little water is removed, being less than 0.5%. The greater amount of residual soap in oil, the more water it holds in solution.

Analysis of tall oil soap by both the TAPPI and AOCS methods for tall oil yield gave the following results. TAPPI method, 61.8%; AOCS method, 62.4%. Actual average yield for the period March, 1958, to March, 1959, in pounds of tall oil per 100 lb. of soap used was 58.7%. Yield in per cent of total theoretical in each case would be.

$$\frac{58.7}{61.8} \text{ or } 95.1\% \qquad \text{(TAPPI)}$$

$$\frac{58.7}{62.4} \text{ or } 94.2\% \qquad \text{(AOCS)}$$

This 95% yield represents a figure at least 5 or 6% higher than generally credited a batch process. We feel it is the use of modern equipment and improved operational techniques throughout the process which are responsible for this. Also, the analyses of tall oil by the consumer of our production has shown it to be of consistently fine quality.

Centrifuge analysis of the well agitated mixture on a cleanout day, before white liquor was added to dissolve the lignin, was made for ten weeks to measure the amount of tall oil lost per cook. Analysis was on a per cent by volume basis. The average per cent loss was 0.71.

Spot checks on per cent black liquor solids in soap processed ranged from 0.8 to 5.5%, the average of several checks being 3.0%. This low figure is borne out by the fact that the average consumption of 66° Bé acid for the year 1958 was 366 lb. per ton of tall oil produced.

Now that the plant has been in operation for over $2^1/_2$ years, and we have had the opportunity to determine its efficiency, its quality of product, its ease of operation and low maintenance cost, we at Chesapeake are well satisfied with our selection of a modern batch process for the production of crude tall oil.

Presented at the meeting of the Virginia-Carolina Section of TAPPI, held in Richmond, Va., Dec. 4, 1959.

PAPERS PRESENTED AT THE 9TH CORRUGATED CONTAINERS CONFERENCE

New Orleans, La., Sept 15–17, 1959

More Press Hours with Rapi-Die Register

D. C. ELLINGER

DURING the early part of 1956 Downing Box Co. requested the Dorr Sales & Engineering Co. of Milwaukee to study their printer-slotter operations and to specifically direct their studies toward a reduction of down time on these machines.

Dorr engineers analyzed the four basic elements of the printer-slotter: the feeding mechanism—ink system—printing system—and slotting and scoring system.

While their analysis of these elements disclosed the possibility of some improvement in each of them, with a view to reduction in down time, their report disclosed that the method of mounting dies by use of staples, and the consequent time required to remove all staples after each press run or during make-ready, was the major down time factor. Thus it was decided to develop an improved means whereby the dies could be premounted and placed on the printing cylinder with a minimum of effort.

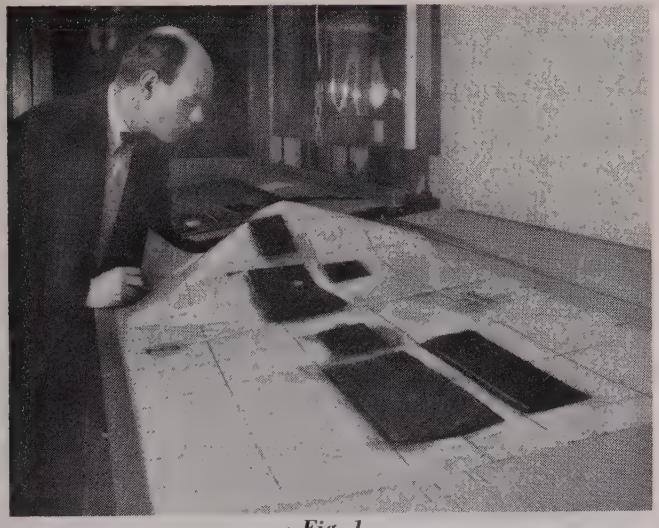


Fig. 1

Considerable time was devoted to study of materials for die blankets and the design and development of a simple mechanism for attaching the premount to the cylinder, and one which could be readily applied to the various makes and sizes of printer-slotters. The result of these studies and development work is the Dorr-Rapi-Die Register, now being sold exclusively by the J. M. Huber Corp. and rapidly gaining recognition in the industry.

As stated before, the basic purpose of the project was the reduction of excessive down time. However, it developed that improved control of register was equally advantageous. The three requirements for perfect register are (1) angular, (2) lateral, and (3) parallelism. The first two requirements can be controlled mechanically on the machine by the press operator. Parallelism has in the past been controlled by the die mounter and the pressman with the ever-present possibility of human error. With the Dorr attachment the human element is greatly reduced with the result of improved register with controlled parallelism.

D. C. ELLINGER, Development Engineer, Downing Box Co., Milwaukee, Wis.

Figure 1 shows the backing material with grommets and with dies glued in place. The backing sheet is Mylar, a polyester film 0.0075 in. thick. It is dimensionally stable and cannot be stapled without permanent injury. Note the grommets which are placed precisely on $4^1/_4$ in. centers.

The backing material shown in the background is an impregnated fabric, 0.030-in. thick, not completely stable dimensionally, can be stapled. These two materials are used interchangeably even though there is a radial difference in thickness of 0.0225 in. It has been determined that a variation of ± 0.080 in. in the diameter of the printing cylinder and dies causes a scuff factor of only 0.005 in. which affects register very slightly. However, an accumulation of such factors with worn pull rolls can result in register problems.

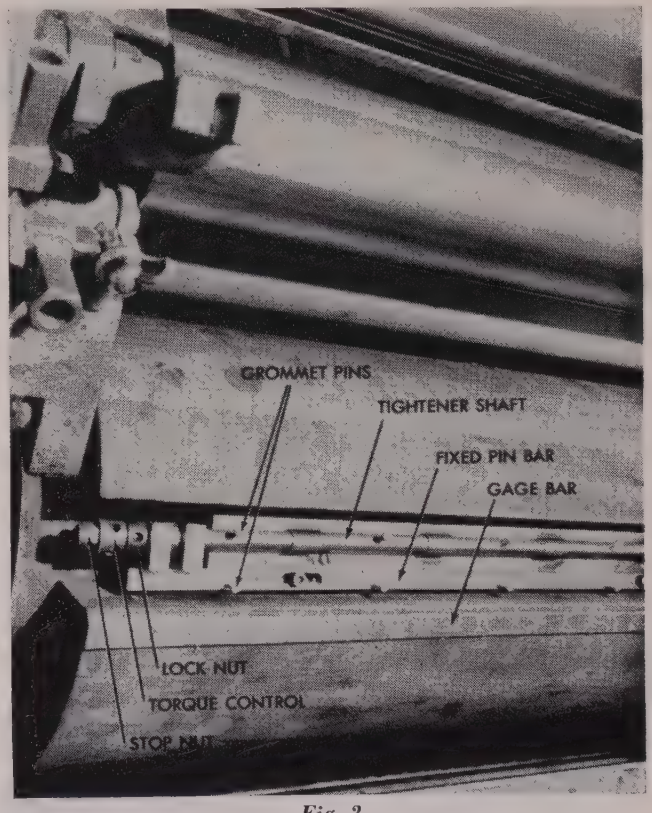


Fig. 2

The mechanism shown in Fig. 2 is not an intricate one but all parts are precision made. As demonstrated in Fig. 3 one grommeted edge of the die mount is placed over the pins on the fixed pin bar. The cylinder is then rotated, wrapping the die around the printing surface. These pins are so designed that the grommets after being pressed into place do not tend to slip off. The other grommeted edge is then placed over the pins on the tightener shaft (see Fig. 4). After the grommets are in place, a small bar is inserted in the torque control and a slight turn tenses the sheet around the cylinder. This torque nut is tapered and slippage will occur if excessive pressure is applied. The stop nut is the adjustment for setting the amount of torque and a setting of 30 lb. is recommended by Dorr.

A twist of the lock nut as shown in Fig. 5 secures the unit.

Fig. 3

Fig. 5

The dies are completely mounted and ready to run as shown in Fig. 6.

In addition to the full wrap unit as described an auxiliary fixed pin bar is also available. This unit is installed at a predetermined circumferential distance from the main unit. This makes possible the "jumping" of dies from one size printer to another. When not in use this bar is covered by the grooved lagging as shown in Fig. 7. A 50-in. machine might have two such bars at 30 and 42-in. thereby maintaining versatility to the operation of the printing department.

With this improved method of applying dies we have realized a saving of about 15 minutes per setup where the dies are premounted on grommeted material. Any dies that formerly were mounted on permanent backing we can mount on the grommeted material more favorably. After the dies are in place on Mylar and any needed adjustments have been made to attain register, these premounts can be rerun again and again without any tendency to shift or stretch. As mentioned earlier, Mylar is a dimensionally stable material. We have found that when dies must be removed, the backing is not damaged due to stretching and Mylar is very difficult to tear in any manner. We have found that removal of dies from other backing material invariably stretches the material and renders it unusable.

Fig. 4

Fig. 6

Fig. 7

We have also found that on reruns the number of throwout sheets required to get the job under way is greatly reduced. Seldom are more than two or three sheets wasted in bringing the plates into good register.

Some saving can be realized in the reduction of the usual periodic relagging of cylinders. This saving depends upon the percentage of dies that can be premounted and thereby eliminate stapling. This equipment has been beneficial in improving our run time to down time ratio even though at present we have not more than 15% of our plates mounted on grommeted backing. We are converting as old premounts become unusable and worn out. New repeat orders are being premounted for application to this equipment. We consider this method of mounting dies to cylinders of printer-slotters to be a worthy contribution to this operation in our industry. There are improvements to be devised and certainly there will be continued development in this area.

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Semichemical Corrugating Medium

J. HAM

As a background for the discussion of modern and future corrugating medium, we should discuss the progress and development of medium up to the present time.

In the early part of the 20th century, corrugated boxes were making their start. They were being recognized as a convenient, flexible substitute for wooden crates and packages. Corrugating medium was used then, as today, to hold two pieces of liner apart and impart cushion and protective characteristics to the box.

The corrugating medium was made of straw, primarily wheat, oat, and rye. The supply of raw material was good, these crops being raised as cash crops throughout the middle west. The medium was made at 30 to 36 lb. per 1000 sq. ft. From 1920 to 1940, fourdrinier kraft test liners were introduced and kraft corrugating medium was used extensively because of excess kraft mill capacities.

The kraft medium was a more uniform product and this uniformity was required because of the introduction of the "B" flute in corrugating. The medium also found wide acceptance in the manufacture of boxes for canned goods because the superior tearing strength resisted the cutting action of the can chines at the box score lines.

The war years found the corrugating industry making special media to be used in shipping containers which had to be waterproof for overseas shipment of supplies. Resin impregnated media in combination with specially treated liners were used to produce boxes which could be thrown into the water and still protect their contents. Heavy weight mediums were developed during the war which were combined with heavy liners to make extremely rugged boxes for motor parts, shell boxes, etc.

Demand for corrugated containers was constantly growing, and to meet it, the bogus medium was introduced. This is made of wastepaper, primarily on cylinder machines. Some of these machines, shut down and idle for years, were put into operation on this new product.

The latter part of the 1940's saw the introduction of the semichemical media. Both kraft and neutral sulfite semichemical cooking processes were used; the neutral sulfite process was the most widely accepted. The neutral sulfite semichemical process, in brief, utilizes various hardwoods such as oak, chestnut, birch, maple, beech, gum, or aspen depending on the mill's location and the wood supply available. The process was hailed as a great step forward since it utilizes trees which were formerly thought unsuitable for papermaking.

The wood, delivered to the mills in 4 or 8-ft. lengths, is generally debarked before chipping although some mills do not bark their wood. It is chipped and sent to cookers or digesters. Several different types of digesters are used; tumbling globe rotary digesters, stationary digesters, and a variety of continuous cookers. In the digesters, the chips are mixed with cooking liquor which is generally sodium sulfite and sodium carbonate in solution. The chips and liquor are heated with steam and the cooking process softens the chips. The cooking is carried out at about pH 7, this being the source of the term *"neutral"* in the name of the process. Not enough chemical is used to completely break the chips down to fiber (in contrast to full chemical cooks such as kraft and acid sulfite) and this fact gives use to the term *semichemical.*

After cooking, the chips are defibered mechanically using one of several disk refiners or defibrators available on the market. After defibering, the stock is generally washed in order to get a cleaner pulp. Washing is also carried out to remove the cooking liquor which is highly corrosive to pipe lines and equipment in the subsequent processes leading to the manufacture of the finished board.

After washing, the pulp is generally further refined using either disk or jordan type refiners and is then supplied to the paper machine.

The neutral sulfite process produces a medium of superior stiffness using "weed" trees. It takes relatively little cooking chemical and the yields are high. The medium contributes to the manufacture of boxes which have superior impact resistance and compression characteristics.

There were, and still are, problems in the use of this type of medium. The medium was relatively abrasive, did not always take glue well, sometimes it did not form properly and of course had the problems common to all paper; wet and dry streaks, caliper and basis weight variation, etc.

A great amount of money and effort has been expended by both converters and producers of corrugating medium in an effort to overcome these and other problems. Pulp cleaners

J. Ham, American Box Board Co., Filer City, Mich.

and screens are being installed in many mills to remove unwanted foreign material from the sheet, and aid in producing higher quality, less abrasive, more uniform board.

The glue penetration problem varies considerably with the wood used in the production of the pulp, but most manufacturers who have the problem are using an additive in their pulp furnish to enhance the rewetting properties of their medium. This allows rapid glue penetration, and better bonding on the corrugator. Converters, working with equipment manufacturers and glue suppliers, have improved and modified machines and adhesives to run the new medium efficiently.

Part of the trouble with poor flute formation has been tied in with the moisture penetration problem. Use of the additive mentioned above, and the use of steam showers and preconditioning equipment on the corrugators have helped to minimize these problems.

Basis weight and moisture variations have been attacked by most medium manufacturers and the use of automatic moisture control systems and automatic basis weight controllers on board machines is widespread. The converter also has been keeping pace by machine improvements, higher speeds, and improved operating procedures.

Testing of the medium, both by the manufacturer and the converter is continuing to improve. At present our mill checks basis weight, caliper, Hart moisture, oven moisture, water penetration, and flute crush resistance on every reel of paper. In addition, spot checks are made at intervals in the reel. Experimental changes in the medium are evaluated by our own container plants as to runnability and box quality.

We also attempt to work closely with our customers in setting realistic limits on our test values and in evaluating techniques and procedures of testing so that we both are measuring the same thing the same way.

We still have problems to work out; score line cracking caused by the increased stiffness of the medium, cutting at the score line when packaging canned goods, etc.

Aside from the every day operating problems with regular medium, there are various specialized applications of corrugating medium which are also very much in the lime light today. One of the greatest problems at the moment is the production of a box which will maintain its stacking strength under conditions of high humidity. The frozen meat, poultry, fruit and vegetable, butter and lard industries require corrugated containers which do not soften when stored under high humidity conditions and lose their compression strength to the point where the boxes collapse when stacked in storage.

Corrugating manufacturers attack the problem in many ways. There are boards available which do a commendable job under conditions of high humidity. I do not believe any manufacturer has the ideal medium as yet, but most of us are working very hard on this problem.

Other fields of endeavor include the effort to make a medium which will not have the effect of tarnishing the goods carried in it.

There is a definite need for a fireproof box. Steps are being taken to accomplish this. Antimold boxes for the packaging of fruits, vegetables, and soaps are needed. It would be advantageous to manufacture a box which could be used at harvesting time for fruits and vegetables and also could be used for display and delivery to the ultimate consumer. This would have to be a rugged, weather resistant, attractive box, which would result in the streamlining of the harvest-to market cycle.

A container which is of importance now, and is very probably going to be extremely important in the future, is one that in itself is not radioactive and will protect its contents from the effects of radioactive fallout. Such a box for food and medicines might be necessary for our very survival. Certainly, right now, radioactive fallout is of great concern to the manufacturers of photographic film.

As we progress in the conception and manufacture of such boxes it appears that we must continue to confine ourselves to using natural products as our raw materials from the standpoints of availability and economy.

As in the past, progress in containers must be preceded by close cooperation and exchange of ideas between the producer of the board and the converter. It is of increasing importance that this cooperation and understanding be expanded. If the manufacturers of medium and liner know what the converter needs and the converter knows the capabilities of the manufacturer, a working, progressive relationship will develop. Such a relationship is essential to the continued growth in size and diversity of the packaging industry.

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Kraft Liners for Corrugated

P. F. HOOD

In 1958 almost 12 billion corrugated and solid fiber shipping containers were manufactured in the United States. To make these 12 billion boxes, and meet export demands (*1*), the containerboard mills produced 4,818,300 tons of linerboard materials of which over 4 million tons were liners manufactured from virgin wood pulps. This virgin fiber linerboard, or kraft linerboard (*2*) as it is most commonly known, constituted 84%, on a tonnage basis, of the total liner materials used last year.

Today the fiber box is recognized as the universal shipping container of commerce. It is acceptable to every commercial carrier—air, rail, truck, and boat; and it is used to carry and protect almost every type of product manufactured or grown. Reliable sources (*3*) estimate that almost 95% of all packaged freight is carried in corrugated or solid fiber boxes, and many of the bulk commodities and items still shipped in wooden or wire-bound crates have corrugated pads and interpacking to protect them from damage.

The success of the fiber box can be attributed mainly to the fact that the industry continually improved the strength and appearance of the fiber box to keep pace with the physical and structural requirements demanded of a shipping container by commerce, while maintaining the cost for it within reasonable limits.

To do this the fiber box industry has demanded stronger and better raw materials from its suppliers. In terms of liner materials, this has meant, in effect, stronger and better linerboard at the same or lighter basis weight.

FACTORS FOR SUCCESS

Strength and Availability

The fiber box was developed as a cheaper shipping container than the wooden box—cheaper to make, cheaper to handle, cheaper to ship, cheaper to dispose of. This economic feature was probably the sole reason the early shippers switched to fiber; but, the two factors which have contributed more than anything else to the present day success of the fiber box have been, (1) the strength improvement of the last 25 years, and (2) availability.

It is commonly said that most materials are precious when they are scarce. This has not been the case with the fiber box. The fiber box has its usefulness through its availability—availability to every industry, large or small, rich or poor. Available by the billions, completely fabricated, ready for the product; or available by the billions, ready to be set up with a minimum of effort and expense into forms especially designed for the product. Because of its avail-

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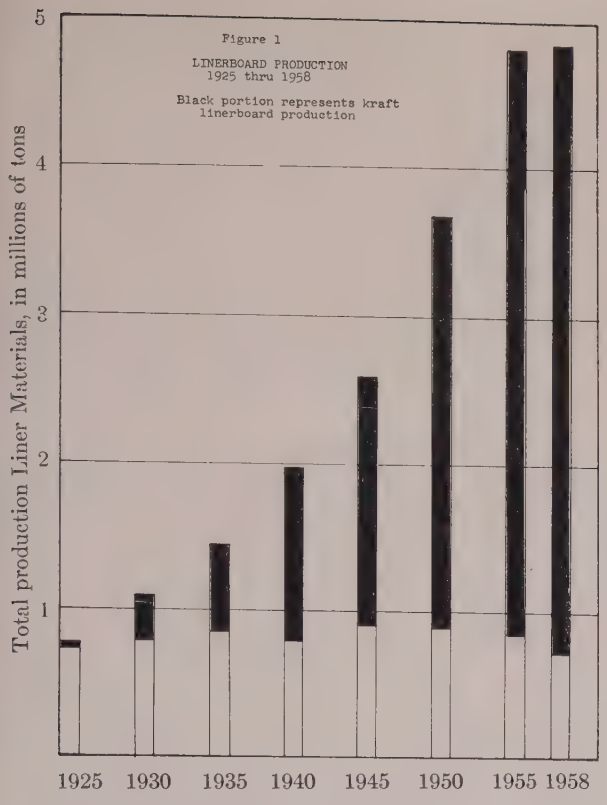

Fig. 1. Linerboard production 1925 through 1958

Black portion represents kraft linerboard production.

ability, industry has come to think first of the fiber box as the shipping container for its products; the fiber box, on the other hand, has been able to capture industry because it had the strength, the toughness, the flexibility to do the job that industry wanted of a shipping container.

Linerboard manufacture on high-speed, high-production fourdrinier paper machines, from virgin kraft wood pulps, have given the fiber box industry the backbone and the muscle it needed to meet the requirements of commerce. First, kraft linerboard gave the industry an ever increasing supply of raw materials on which it could rely, a supply of raw materials not dependent on secondary accumulation but upon the growing tree which could be harvested. Secondly, it gave the industry a strong raw material at a lower cost because virgin fiber board could make satisfactory shipping containers with less weight. Thirdly, and most important today, the kraft industry, through the development of stronger pulps, has been able to manufacture stronger linerboard from which stronger boxes have come. The kraft industry has been able to produce more attractive boards and better printing boards without sacrificing strength characteristics or increasing weight.

The Budding Year—1931

Although the fiber box was born in 1903, and acquitted of the role of substitute container in 1914 by the Pridham decision, the year 1931, a year many still remember as the blackest in this country's economic history, is the year the fiber box industry must, unhesitantly, call its budding year.

It is true that the fiber box industry was firmly established long before 1931; but, nevertheless, this was the year that saw the development that, overnight, refashioned the pattern of the industry. The year 1931 marked the startup of the first kraft mill devoted entirely to the production of containerboard from virgin wood pulp—the beginning of mass production as we know it today, the technique that ultimately made the fiber box "available."

It is remarkable that this mill, brought into production

Table I. Average Fiber Length of Common Species Used for Linerboard Pulps

	Fiber length, mm.
Coniferous Woods	
South	
Longleaf pine (*Pinus palustris*)	3.70
Loblolly pine (*Pinus taeda*)	3.00
Short leaf pine (*Pinus echinata*)	3.70
West Coast	
Douglas-fir (*Pseudotsuga taxifolia*)	4.50
Sitka spruce (*Picea sitchensis*)	3.50
Western yellow pine (*Pinus ponderosa*)	3.60
North	
Balsam fir (*Abies balsamea*)	3.00
Hemlock (*Tsuga canadenses*)	2.90
Jack pine (*Pinus banksiana*)	3.50
Broadleaf Woods	
Aspen (*Populus tremuloides*)	1.15
Chestnut (*Castenea dentata*)	1.00
Black Gum (*Nyssa sylvatica*)	1.70

in a depression year, when few people were buying things and most manufacturers could hardly afford to package the things they sold, should be so important to our industry. But this mill, located in Panama City, Fla., and built to produce 225 tons per day, emphasizes the whole kraft industry of today, which now produces more than 10,000 tons of linerboard every 24 hr. Today Panama City makes more than 1600 tons of kraft containerboard (*4*) per day on the two original paper machines which started production in 1931. Panama City symbolizes the tremendous manufacturing facilities of the fourdrinier kraft board industry.

Following Panama City, kraft linerboard mills began to dot the South, and the fiber box industry began to grow. Kraft linerboard provided the backbone for this growth, supplying all the new tonnage needs of the industry. Figure 1 shows the production of liner materials from 1925 through 1958. The black portion represents kraft linerboard; it can be seen that the black portion is the growth of the industry. Kraft linerboard has grown from 2.6% in 1925, to 32% in 1931, to a mammoth 84% of the industry in 1958.

The Virgin Fiber—What Is It?

Many papers have been written that state, somewhere in their contents, something like this: "All factors being equal, virgin pulps have the longest fibers and produce the strongest boards." No one disputes this statement but just what, in terms of rational figures, does it mean?

Kraft pulp is manufactured by a process which chemically reduces wood to fiber form, or pulp. This process is called the sulfate process (*5*) after its basic chemical, sodium sulfate (*6*). Wood, contrary to the layman's thinking, is not a solid, homogeneous substance like steel or glass. It is made up of

Table II. Beater Evaluation of Kraft Linerboard Pulp and No. 1 Grade Wastepaper Pulp

	Unbleached kraft linerboard pulp[a]		*No. 1 grade wastepaper pulp*[b]	
	500 C.S.[c] *freeness*	*300 C.S. freeness*	*500 C.S.*[c] *freeness*	*300 C.S. freeness*
Power factor, kg.-min./cc.	2.5	1.6	0.34	4.1
Beating factor, kg.-min.	535	674	6	89
Mullen, %, pt./lb.	138	144	41	75
Tear factor,	145	134	116	137
Apparent density, lb./pt.	10.3	10.8	8.1	8.5
MIT Fold	320	332	12	76
Tensile, lb./in. width	34.4	35.8	12.2	20.0
Breaking length, meters	10,240	10,620	3770	6150
Tabor V-5 stiffness	2.4	2.3	1.6	1.8

[a] Unbleached kraft linerboard pulp was commercial grade southern kraft linerboard pulp as used for 42–100 lb. test board.
[b] No. 1 grade wastepaper pulp was commercial grade, 100% box plant clippings, complete furnish for 50–100-lb. test board.
[c] Normal pulp evaluation is at 500 Canadian Standard freeness.

innumerable little, hollow, round tubes of cellulose, usually closed at the ends, called fibers. In particular wood the great proportion of the fibers are very similar, but the fibers vary significantly between different species of woods. Most of the fibers in a piece of wood are arranged vertically in a standing tree and are cemented together by what is known as lignin. In the South where 82% (*7*) of the kraft board is manufactured, the principal wood (*8*) used is the southern yellow pine, which is fast growing and produces long and very strong fibers.

The sulfate process of manufacturing pulp from wood utilizes chemicals that do not weaken the fiber in the cooking process as much as other types of pulpmaking processes, and therefore, the fiber (*9*) produced for kraft linerboard is the strongest commercially available.

The purpose of the chemicals used in the sulfate process is to dissolve the cement-like lignin and free the cellulose fiber so that it can be utilized as a papermaking material.

Contrary to some belief, the length of the fiber produced by the pulp making process is, for all practical purposes, as the length of that fiber when it existed in a tree. Table I shows the average fiber length of some of the common species used to make draft linerboard pulps. As some kraft mills use small amounts of hardwoods (*10*) in linerboard manufacture this table includes the fiber lengths of three broadleaf or hardwood species, namely Gum (*Nyssa sylvatica*), Aspen (*Populus tremuloides*), and Chestnut (*Castenea dentata*).

Virgin fiber pulp, as it comes initially from the pulp mill, cannot be made into a sheet of paper or board. The fibers first have to be refined or hydrated so that they will bond together and give the sheet strength. The strength of a sheet of paper or board depends on the degree of refining of the fibers and the length and nature of the fiber itself, i.e., the species of wood from which it came, the type of pulping process, the efficiency of the pulping process, and the efficiency of the papermaking process. The paper mill can evaluate a pulp by refining it in the laboratory under standard conditions and testing it at various stages of the refining process so that a strength chart can be made. These charts reflect the strength of the pulp and what might be expected from that pulp when run on a paper machine.

Table II shows a standard beater chart for a typical kraft pulp manufactured at one of the Southern linerboard mills. This illustration also shows the same type of data for a pulp made from a no. 1 grade of wastepaper (*11*), 100% box plant clippings. From these data the inherent strength of the virgin kraft fiber is readily apparent. The burst is considerably higher and tear (*12*), fold, tensile, and stiffness tests also show the greater strength of the virgin kraft fiber.

The beater charts have explained the statement made previously, "all factors being equal, virgin pulps have the longest fibers and produce the strongest boards." In effect, they explain why kraft linerboard can be used in a lighter basis weight to meet rule 41 mullen specifications. But, and probably more important, these data show the strength of the virgin fiber in terms of characteristics other than mullen, which are so important to the performance of fiber boxes. These are tear, tensile, fold, and stiffness. These properties give to kraft linerboard the toughness needed to make strong, protective shipping containers.

THE FIRST FIBER BOX OBSTACLE

Brittleness

In the early 30's this toughness of the virgin fiber (as kraft linerboard) enabled the fiber box industry to overcome its first major obstacle—brittleness and weak flexural strength of the liners. Some called it weak flaps, splitting, cracking, rotten board; but regardless of the terminology a grave problem existed.

The brittleness and poor bending qualities of prekraft liners was caused by two factors; (1) it was manufactured on cylinder machines which produced very directional boards, strong in one direction, weak in the other direction; and (2) the short fiber, weak waste pulps from which it was manufactured.

The early 30's was known as the "weak-flap" era. Scoreline splitting and cracking was very prominent and very discouraging. Often a person would bend a flap over to close a box and find himself holding two pieces—the flap in one hand and the rest of the box in the other. The flaps would break off completely. For this reason, exceptionally wide scores ($^1/_4$ in. or wider) had to be put in the boxes to minimize as much as possible the strain on the liner at the scorelines. (Some people think they have cracking problems today but it is nothing as compared to the cracking problems in the prekraft days.)

During the "weak flap era" many companies frowned upon the fiber box as an adequate shipping container for anything but light, cheap products. Industry was reluctant to spend money to adapt its packaging lines to fiber boxes because of the uncertain strength characteristics.

Kraft Overcomes Brittleness

It was only 34 years ago that the Brown Paper Mill Co., West Monroe, La., manufactured the first virgin kraft fiber linerboard. During the next 5 years, 1925 to 1930, several kraft mills toyed, more-or-less experimentally, with the production of linerboard from virgin fiber, but none went into it on a large scale principally because of the caliper requirements of rule 41. In order for the kraft mills to produce a sheet with 0.016 caliper, the law (*13*) of the land for 100 lb. test board, it was necessary to "fluff-up" the board to the point that the fibers could not be refined properly to get the specified burst (*14*). For this reason it was necessary to run a 50-lb. (MSF) sheet and even then it was extremely difficult to maintain the caliper. Therefore, the economics of virgin kraft linerboard in the years 1924 to 1930, prohibited its widespread development, even though there were many kraft mills at that time that needed business (*15*).

Therefore, in 1931, when the Panama City Mill came into production, the problem was not how to make a satisfactory sheet of linerboard to conform to rule 41 but how to make money on it. The advantages of mass production enabled this mill to operate profitably where other mills were losing money.

As the use of the Panama City product spread, it was noted that kraft boxes did not have the brittleness of the "weak flap," which was the principal drawback of the fiber box at that time. Boxmakers soon learned that they could reduce the width of the scoreline on kraft boxes (to present day practices) and produce stronger and sturdier containers. The frown on the face of industry gradually turned into a satisfied smile. Virgin kraft linerboard had overcome the first real obstacle in the path of the fiber shipping container.

The Battle—Caliper Versus Weight

The kraft linerboard produced during the 10 years from 1931 to 1941 was a very bulky, porous, coarse, rough sheet but nevertheless it made a great impression on the trade because fiber box manufacturers soon learned that with kraft linerboard they could make a superior box at low cost.

Actually from 1925 to 1941 there were no basic material changes made in the specifications set by the Consolidated Freight Classification Committee to govern the fiber shipping container. The specifications, which have come to be universally known as rule 41, that were in effect during that time were the same as originally written in 1919 when kraft board did not exist, with one exception (*13*), and the kraft liners produced during this period had to conform to specifications foreign to its nature, and not necessarily in the best interest of the end product—the fiber box.

Table III. Abbreviated[a] Consolidated Freight Classification Table, 1919 to Oct. 1, 1941

Maximum weight of box and contents, lb.	*Maximum dimensions; length, width, and depth added, in.*	*Double-faced corrugated strawboard[b]* — *Facings* — *Minimum thickness, in.*	*Facings* — *Minimum mullen, p.s.i.*	*Combined board; minimum mullen p.s.i.*
20[c]	40	0.009 (30 lb. DF)[d]	None	125
40	60	0.016 (42 lb. DF)[e]	85	175
65	65	0.018 (52 lb. WF)[e] (47 lb. WF)	100	200
90	70	0.030 (85 lb. WF) (90 lb. WF)	135	275

[a] Omitting list of box styles, solid fiber, double wall specifications.
[b] Up to 1926, corrugated board was called *strawboard* because it was the only medium used.
[c] 125 lb. classification added Oct. 1, 1941.
[d] DF = dry-finished board.
[e] WF = water-finished board.

Table III shows rule 41, in abbreviated form, that was in existence up to 1941. The basis weight (lb. per MSF) and grade of kraft linerboard being produced to conform to this specification are given in parentheses.

This is considerably different from rule 41 of today, as shown in Table V, where 38, 42, and 69-lb. liners can be used, respectively, for the 175, 200, and 275-lb. classifications.

DEVELOPMENT OF THE SECONDARY HEADBOX

In the middle '30's industry began to think of the fiber box as more than just a shipping container and started considering its salesmanship—its advertising potential. Box plants found themselves being pressed for more and better printing on their boxes. It was extremely difficult to print on the dry-finished sheet of kraft linerboard and even the water-finished grades were extremely porous. In many cases the only way the box plants were able to get the desired printing surface was to use heavier liners than there was a functional need for, which cost money. Therefore, the box plants demanded a better printing surface on 42-lb. dry-finished linerboard and these demands were answered with the development of the secondary headbox by Hummel-Ross in 1938.

The secondary headbox completely changed the production technique of kraft linerboard. By use of the secondary headbox, a top layer of highly refined, dense, closely matted fibers could be placed on top of the rough, porous sheet that the mills had been producing. This dense top layer, or secondary sheet as it came to be known, made a considerable improvement in the printability of the dry-finished kraft linerboard.

This was a great forward step for the industry and today most modern fourdrinier linerboard machines are equipped with secondary headboxes and the secondary can be used on all grades, from 26 to 90 lb.

RULE 41 REVISED

In 1941 the 125 lb.-test box was authorized to meet the demands of industry for a cheaper nontest container. However, it was imminent at the time that major revisions of rule 41 were needed because of (1) the strength of kraft linerboards being produced (which had grown to be 58% of the industry); and (2) the trend in merchandising practices away from bulk handling to the use of small, light, efficient containers.

Table IV. Abbreviated[a] Consolidated Freight Classification Table, March 17, 1942 to Dec. 6, 1943

Maximum weight of box and contents, lb.	*Maximum inside dimensions; L + W + D added, in.*	*Corrugated, minimum combined thickness of facings, in.*	*Board, minimum combined board mullen test, p.s.i.*
20	40	0.018 (26 lb. DF)[b]	125
40	60	0.028 (37 lb. DF)	175
65	75	0.032 (42 lb. DF)	200
90	90	0.046 (69 lb. WF)[c]	275
125	100	0.060 (90 lb. WF)	350

[a] Omitting solid fiber and double wall specifications.
[b] DF = dry-finished board.
[c] WF = water-finished board.

Table V. Abbreviated[a] Consolidated Freight Classification Table, Jan. 15, 1945 to Date

Maximum weight of box and contents, lb.	*Maximum inside dimensions; L + W + D added, in.*	*Corrugated, minimum combined weight of facings, lb./msf[b]*	*Board, minimum combined board mullen test, p.s.i.*
20	40	52 (26 lb. DF, SF)[c]	125
40	60	75 (38 lb. WF)[d]	175
65	75	84 (42 lb. WF)	200
90	90	138 (69 lb. WF)	275
120	100	180 (90 lb. WF)	350

[a] Omitting solid fiber and double wall data.
[b] lb./msf = lb./1000 sq. ft.
[c] DF = dry-finished board.
finish or steam finish board.
SF = spray finish or steam finish board.
[d] WF = water-finished board.

For this reason rule 41 was ammended in 1942 as shown in Table IV. This revision was the first real recognition of the strength of kraft linerboard, which meant (in terms of kraft that-

0.014—38 lb. replaced 0.016—42 lb. for 175 test boxes
0.016—42 lb. replaced 0.016—47 lb. for 200 lb. test boxes
0.023—69 lb. replaced 0.030—90 lb. for 275 lb. test boxes
0.030—90 lb. formed a new, higher strength 350 lb. classification

From 1903 until 1942, for nearly 40 years, 175-lb. test boxes had been fabricated with at least 8 lb. extra weight, 200-lb. test boxes with at least 10 lb. extra weight, and 275-lb. test boxes with at least 32 lb. extra weight (*16*).

In 1943, the present rule 41, as shown in Table V, was adopted. This revision, in which caliper specifications were dropped entirely, being replaced with minimum weight requirements of the facings, was heartily accepted by the kraft industry. Although this revision was in line with the war effort to conserve the use of the vital virgin fiber, nevertheless it removed the barrier holding back the development of draft linerboards.

The Decreasing Caliper

With the caliper restrictions lifted in 1943, kraft mills were able to concentrate on getting the maximum strength out of the virgin fiber. They were able to discontinue research into the development of bulky, fluffy fibers and concentrate research on higher strength fibers. They were able to discontinue manufacturing techniques designed to run bulky, porous linerboards and concentrate on techniques and machine modifications to produce boards of higher strength and improved printing qualities. They were able to increase production which served to make the fiber box "available" to keep up with the expanding economy of the United States.

It was only natural that when the nemesis of kraft linerboard, high caliper specifications, was taken out of rule 41 the caliper of draft linerboard would decrease to the best operating levels commensurate with good quality.

And that is what has happened. Everything the kraft mills did to improve quality or production was at the expense of caliper. In 1949 smoothing presses were added to linerboard machines, second sets of calender stacks were installed, and then breaker stacks, all designed to increase production and improve quality, mainly printing surface and runability on the corrugator.

Although there are some people who might dispute this statement, it is generally felt that the elimination of caliper from rule 41 was a good step for the industry and has resulted in stronger and better corrugated containers. By running to a floating caliper the mills were able to run to the

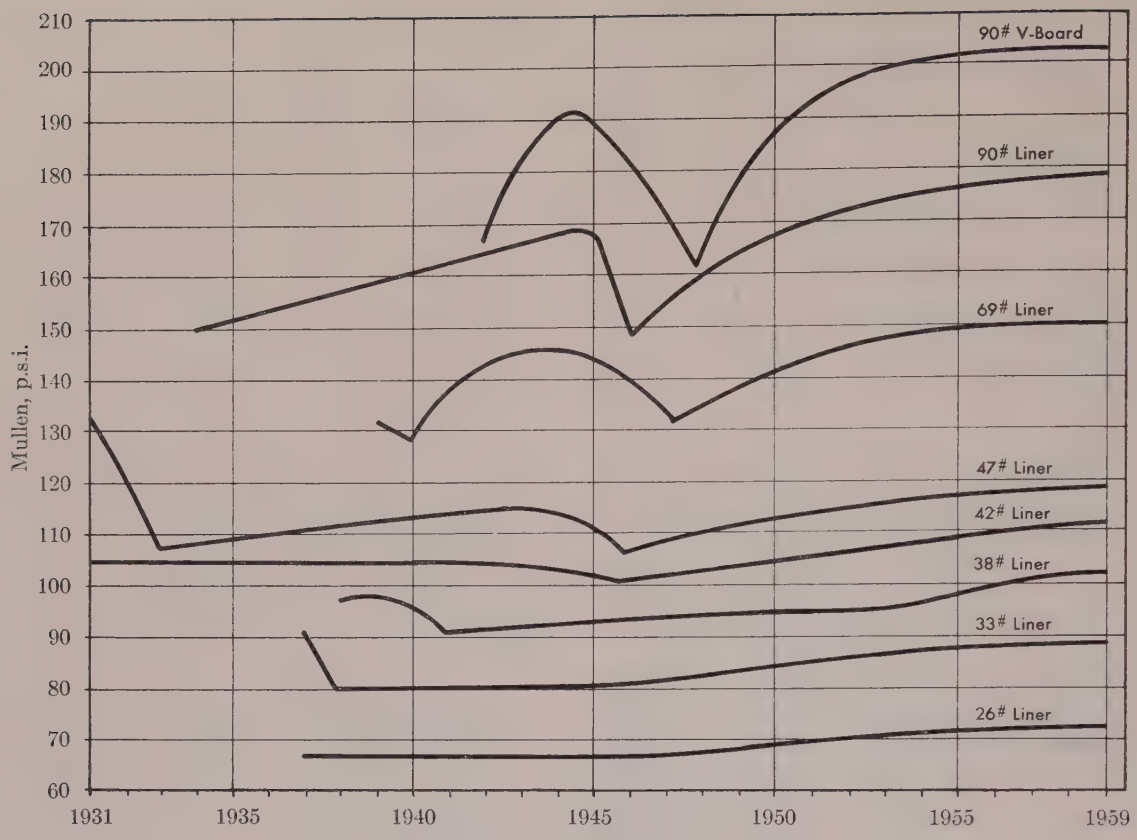

Fig. 2. Mullen-Kraft linerboard 1931–1959

best finish obtainable and maintain uniformity of that finish. The lower caliper boards produced a denser product that did not have the weak spots common to the bulkier 0.016-in. sheet. Box plants were able to increase their corrugator speeds because the denser linerboards ran better, were more uniform in moisture, and caused less adhesion problems (*17*). From better and more efficient fabrication techniques better boxes were produced.

Subsequent data are presented to substantiate that the strength of kraft corrugated boxes has improved over the years, even with decreasing caliper.

A New Board Property—Scuff Resistance

Still, the secondary headbox and the other efforts of the kraft mills to improve printing quality were not enough to satisfy the demands of an industry which had in 1949 come to recognize the tremendous advantages of the fiber box to industrial advancement. The high strength fiber box was showing industry the way to mechanize packaging and handling lines, and many companies were subjecting the fiber box to abuses of industrial processes that heretofore were unknown. There were demands for more attractive boxes but the boxes had to also have the ability to withstand multiple handling.

This caused a new linerboard quality to be born—resistance of the liner to scuffing.

The glass industry, recognizing that better printability and better scuff resistance was of great importance to them, pushed for improved scuff resistance on the 42-lb. dry-finished board and this led to the development of water finished 42-lb. kraft linerboard in 1949, and subsequently to the water finishing of 38-lb. liner in 1958.

V AND W BOARDS

Prior to World War II, the fiber box was confined largely to domestic use because of the inability of some of them to withstand damp storage conditions and severe handling of export shipments.

The strength requirements for export shipments were so much greater than could be produced from the linerboard materials available at the time that it was necessary to invent new and stronger boards and new and ingenious methods of fabricating them into boxes. As the dramatic story of the fiber box in World War II is a story within itself, it will not be

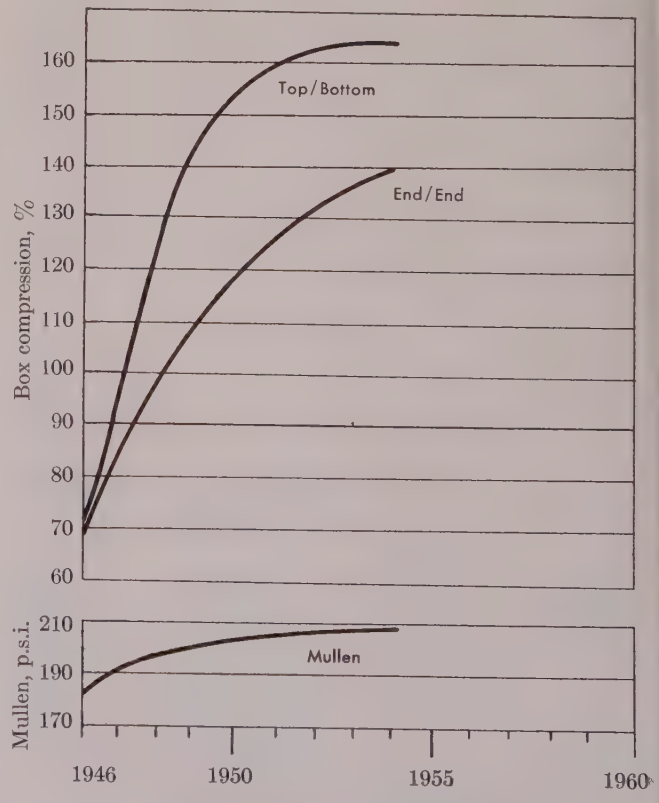

Fig. 3. 150-lb. test containers

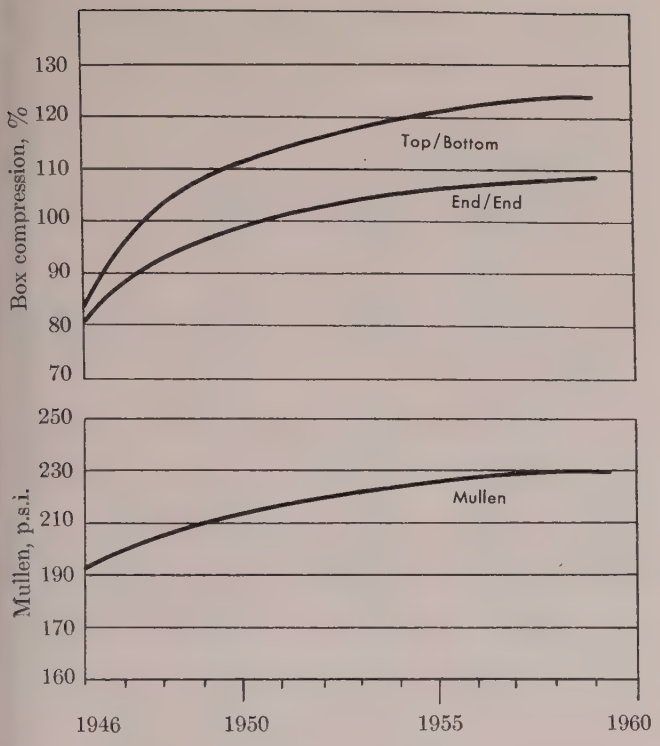

Fig. 4. 175-lb. test containers

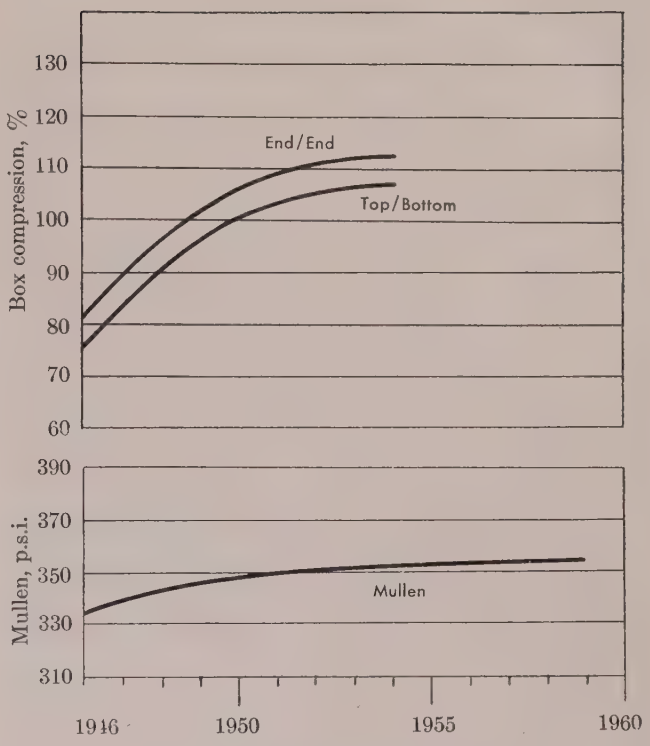

Fig. 6. 275-lb. test containers

elaborated upon here except to state that the development and success of the V and W boxes stands, without a doubt, as a tribute to the strength and toughness of the virgin kraft fiber.

KRAFT BOXES OF TODAY

Since the war, there has been a marked improvement in the strength of kraft linerboard and the corrugated boxes made therefrom, as measured by the burst and compression tests. Of course, with respect to compression and especially top/bottom compression, the effect of the corrugating medium cannot be overlooked but, in any case, the improvement is of significance and the liners have contributed no small part in this improvement. Figure 2 shows the mullen curves for the common grades of kraft linerboards from 1931 through the first 6 months of 1959. These curves contain rather peculiar dips (*18*) which are explained in the Notes section. A definite mullen improvement on all grades is evident.

Figures 3 through 7 show mullen and box compression tests for 150-, 175-, 200-, 175-, and 350-lb. test containers from 1946, the first year reliable data were available, through the first 6 months of 1959.

The compression tests are reported as percentage values of a standard which takes into account the flute and geometric configurations of the box.

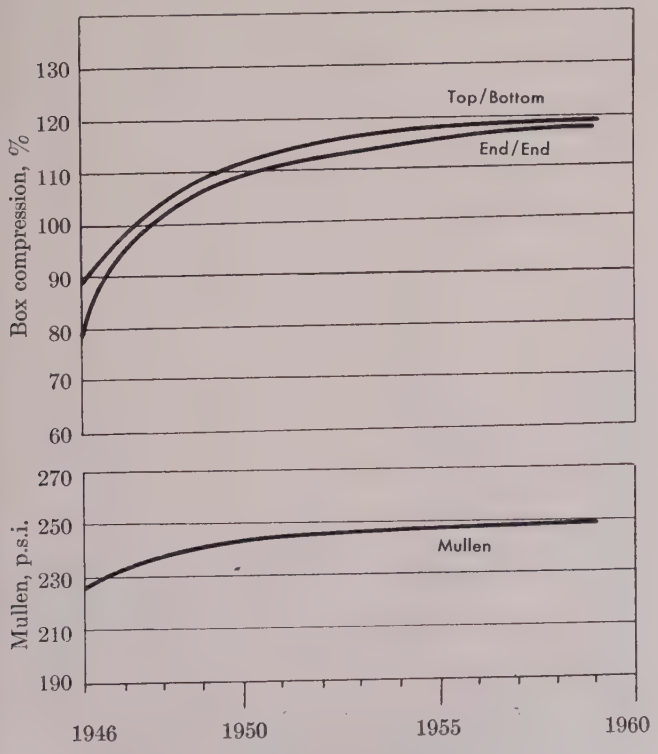

Fig. 5. 200-lb. test containers

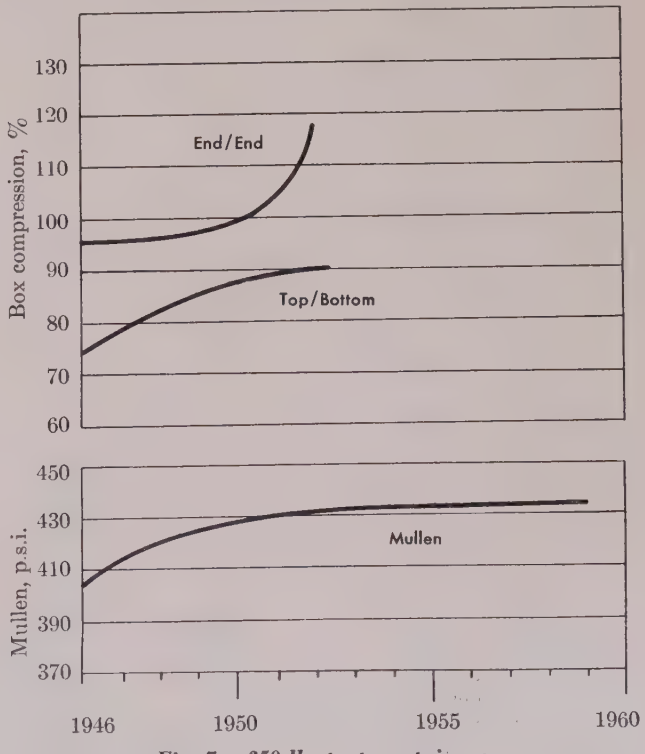

Fig. 7. 350 lb. test containers

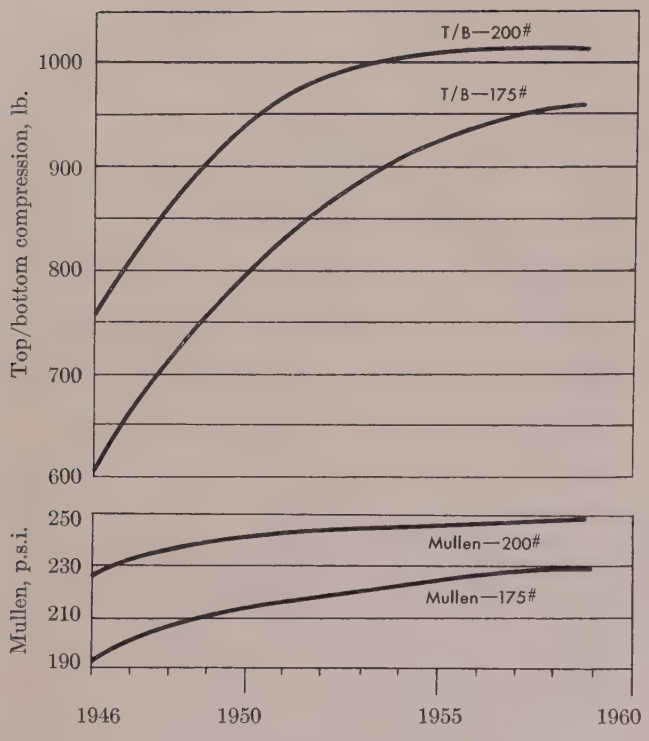

Fig. 8. Comparison 175-lb. and 200-lb. test container, same size box

Box size: $23^1/_8 \times 13^3/_4 \times 20^1/_4$ in.

Combined board mullen and box compression tests have shown marked improvement since 1946. In terms of mullen, which some say has poor correlation with the performance of a fiber box, but nevertheless is of major importance since rule 41 is written around it, the improvement is basic because kraft linerboard has reached sufficient strength to practically relieve the boxmaker of concern about meeting rule 41 requirements.

Figure 8 shows a comparison of mullen and top/bottom compression tests, in pounds rather than per cent for the same size box fabricated from 38- and 42-lb. kraft liners, from 1946 to the first 6 months of 1959. The 1958 to 1959 strength of the 175-lb. test box is as good or better than the 1946 strength of the 200-lb. test container.

THE ACCOMPLISHMENTS OF KRAFT LINERBOARD

Kraft linerboard has contributed much to the success and growth of the fiber box industry. The major points in its development have been discussed in some detail in this paper; however, there are many things that could not be included in the text that nevertheless should not be omitted in any discussion of kraft linerboard. For that reason the following outline is given to cover as completely as possible the whole story of virgin kraft linerboard.

1. Kraft linerboard is a growing source of raw material and can meet growth demands.

2. Kraft linerboard provides a reliable source of raw material on which the box plant can plan for the future.

3. Kraft linerboard provides stabilized price structure for industry.

4. Kraft linerboard brought strength to the fiber box, in terms of:

a. mullen
b. toughness (combination of tear, tensile, folding and stiffness strengths)
c. scoreline strength (compression and tearing to overcome brittleness and weak flaps)
d. higher wet-strength properties
e. higher water-resistance properties
f. less directional box compression (i.e., top/bottom, end/end, side/side are more nearly equal to give a box balanced strength)
g. general durability of boxes

5. Kraft linerboard has resulted in more efficient corrugated operations, in terms of:

a. more uniform moisture control
b. ability to control moisture at best level for grade of liner
c. uniformity of strength from roll-to-roll, order-to-order
d. uniformity of weight control—lighter weight
e. fewer weak spots across sheet
f. fewer foreign particles in sheet
g. better quality for less cost
h. faster speeds on corrugator because of uniformity of quality
i. faster speeds of processing combined board into boxes due to higher strength, less directional strength, more efficient sizing.

6. Kraft pulps have supplied more attractive, cleaner looking, stronger looking linerboard.

7. Kraft linerboard runs more uniform in color from run-to-run.

8. Kraft has been able to make lighter colored boards to meet the demands for better contrasting printing surface.

9. The chemical composition of kraft can be controlled within narrow limits for antitarnishing, anticorrosion, antistaining.

10. Resale value of reclaimed kraft is high.

THE FUTURE

Kraft linerboard became a practical and economic reality for corrugated and fiber boxes in 1931, that being the year its production was genuinely felt by the fiber box industry. For all practical purposes kraft linerboard can be considered as having existed only 27 years, but it has come a long way in that short time.

It is very exciting to contrast the kraft industry of today with the same industry 27 years ago. In a way it is not the same industry. True, board is made in much the same way—some of it, in fact, on the same machines which started producing long before 1931. The difference, however, is real.

In 1931 the Panama City machines, 220 in. wide, were the largest in the world. Today there are machines trimming 252 in. In 1931 the Panama City machines were the longest in the world, 255 ft.; they had a 90-ft. fourdrinier wire, 54 driers, one calender stack, and averaged 350 f.p.m. on 42-lb. linerboard.

Today these same machines are 411 ft. long, have a 122-ft. fourdrinier wire, 100 driers, two calender stacks, and run 1600 f.p.m. on 42-lb. linerboard. The speeds that are commonplace today were only dreams in 1931. Today's standards of precision and control, today's instrumentation, today's quality are all things that have gone far beyond any conception of the mill people 27 years ago. Table VI shows the production records of a typical fourdrinier paper machine manufacturing 42-lb. kraft linerboard. Records on others grades are similar but 42-lb. is shown because it is the most common grade today.

Kraft linerboard today is capable of performing in ways that were out of the question with the 1931 product. Greater strength and stiffness, better printability, and better water resistance per unit weight has made possible service in fields far beyond the imagination of boxmakers in the '30's. Just as the nail keg and the wooden orange crate, which were commonplace 10 years ago, are now things of the past, other packages common today, like the wooden tobacco hogshead, even the traditional cotton bale, may soon be replaced with corrugated. But the future new growth items in corrugated are going to have to be in stronger and better boxes than are available today. Up until now the corrugated business has been so good, and the growth has been at such a rapid pace, that boxmakers did not have to know their product—what it would or would not do.

The low cost of the corrugated box has been the driving

Table VI. Production Record, 42 Lb. Kraft Linerboard

Year	Speed, f.p.m.	Caliper, in.	Mullen, p.s.i.	Finish
1931	329	0.0165	104	0.016 Dry finish
1932	...	0.0167	105	0.016 Dry finish
1933	...	0.0165	104	0.016 Dry finish
1934	433	0.0165	106	0.016 Dry finish
1935	436	0.0169	105	0.016 Dry finish
1936	613	0.0168	105	0.016 Dry finish
1937	715	0.0167	102	0.016 Dry finish
1938	660	0.0165	105	0.016 Dry finish
1939	687	0.0165	105	0.016 Dry finish
1940	704	0.0164	105	0.016 Dry finish
1941	780	0.0162	103	0.016 Dry finish
1942	796	0.0163	104	0.016 Dry finish
1943	721	0.0163	104	0.016 Dry finish
1944	746	0.0144	103	42 lb. Dry finish
1945	772	0.0144	100	42 lb. Dry finish
1946	735	0.0147	103	42 lb. Dry finish
1947	756	0.0148	102	42 lb. Dry finish
1948	793	0.0145	103	42 lb. Dry finish
1949	1060	0.0132	104	42 lb. Water finish
1950	1139	0.0131	105	42 lb. Water finish
1951	1190	0.0131	104	42 lb. Water finish
1952	1214	0.0132	107	42 lb. Water finish
1953	1297	0.0124	109	42 lb. Water finish
1954	1327	0.0127	110	42 lb. Water finish
1955	1417	0.0127	110	42 lb. Water finish
1956	1480	0.0124	109	42 lb. Water finish
1957	1554	0.0125	109	42 lb. Water finish
1958	1467	0.0123	110	42 lb. Water finish
1959	1561	0.0122	111	42 lb. Water finish

force, and there has been up to now ample cost differential between fiber and wood so that if 42-lb. liners did not give sufficient strength, 90-lb. liners could be used and the fiber box would still be cheaper than other available packages.

This is not going to be the case in the not too distant future. Another group of materials, Plastics, which have made great inroads in the food packaging field, are now making inroads to the shipping container field. The plastic typewriter container displayed at the 1959 Packaging Show in Chicago, and a more recent development, the plastic milk delivery case, are both examples of things that are now being done with plastics. It cannot be overlooked that the price of plastics is decreasing and could soon be competitive with corrugated boxes. Neither can it be overlooked that chemical companies can make new types of materials that can be used for packaging and shipping containers, if they can be made so to compete in cost with fiber boxes. Therefore, it looks as if 1959 may be a turning point for the corrugated box industry.

Box makers are going to have to learn their product, learn how to make stronger boxes, and functional boxes, and more attractive boxes, and how to make them more efficiently and more economically to meet the challenge of plastics and substitute packaging methods.

From now on there is going to be a change in box safety factor. Today, if boxes get to the consumer with only occasional damage claims, if the appearance of the shipping container is in fair shape, not excessively scuffed or torn, they are said to be entirely satisfactory—but this thinking is rapidly changing. Advertising has come into the picture and advertising demands perfect boxes every time. The trend in merchandising is to self-service stores where the product is not removed from the container, but where the container itself assures the customer that the product is in good shape, has not been tampered with, is not a floor model that has been used but is just like it left the factory. Many self-service stores, such as liquor stores, are now making attractive displays of stacks of corrugated boxes from which the purchaser makes his selection. The trend today is to buy things in unit packs—a case of beer, a case of soap, a case of assorted baby food. Many other items are going to multiple unit sales. For instance, the cereal companies have made one step in that direction with their ten-packs of individual servings. These are attractively packaged and displayed in the grocery store to catch the customer's eye. But this is not the most satisfactory merchandising technique because the consumer has to buy several units or else he only gets one, or at the most two, servings of each cereal. Some thought is being given to merchandising larger boxes of cereal in ten-packs where the corrugated box will be the eye-catcher.

The corrugated industry faces the following conditions for the future:

1. How to make more attractive containers.
2. How to make effective functional containers more efficiently and cheaper.
3. How to make stronger boxes.
4. How to meet the competition of plastic and substitute packaging methods.

Kraft linerboard mills are already at work on new boards to satisfy the requirements of items 1 and 2 above. Some have already been put on the market, and for interest they are described below. Many of these specialty boards have special names and are identified as such by the trade, but for this paper they are treated in general catagories.

Specialty grades for distinctive appearance:

1. Clay-filled kraft—a light tan sheet containing a high percentage of clay and/or titanium in the secondary.

Table VII. Special High-Strength Kraft Linerboard Evaluations

	33-Lb. linerboard			38-Lb. linerboard		
	Regular Mill a	Special Mill a	Special Mill b	Regular Mill a	Special Mill a	Special Mill b
Components Tests						
Caliper	11.1	9.3	8.0	10.5	10.7	9.8
Mullen	90	106	109	105	120	121
Ring crush						
MD	76	88	75	94	107	99
CD	55	65	51	68	79	66
Tear						
MD	249	236	229	261	291	301
CD	285	286	278	330	350	349
Combined Board Tests						
Caliper	193	192	188	195	196	193
Mullen	200	231	236	227	259	254
G.E. puncture	206	203	209	214	220	231
G.E. stiffness	116	117	120	126	132	123
Pin adhesion	53.8	48.9	45.5	54.9	54.1	42.0
Box Tests						
T/B compression, lb.	744	804	838	929	1003	962
E/E compression, lb.	451	505	492	644	697	626

Note: Same corrugating medium used in all tests, RSC, "A" flute, stitched joint, $22^{3}/_{4} \times 15 \times 24^{5}/_{8}$ in. box size.

2. Mottled kraft grades (*19*). There are numerous grades on the market which have varying quantities of bleached fiber, with and without color, in the secondary headbox furnish to give different effects.

3. Bleached linerboard—a full bleached sheet of 75–80% G. E. brightness.

4. Single, white-lined fourdrinier kraft—a sheet bleached on the top side with a layer of unbleached (natural) fiber on the bottom side. This grade is stronger and runs better on the corrugator than the full-bleached grade. Like full-bleached linerboard this grade is also 75 to 80% G. E. brightness.

Functional or specialized end-use grades:

1. Release-coated linerboard—has the characteristic that few things will stick to the coated surface. Used to package rubber, asphalt or sticky materials.

2. Antiskid linerboard—for application when high coefficient of friction is needed.

3. Mole-resistant linerboard (*20*)—for use where the product packaged promotes mold growth on the boxes.

4. Nonabrasion linerboard—has a surface with less abrasiveness to painted or enameled surfaces than regular linerboard. Still in experimental stage of development.

The last two conditions of the future deal with how to make stronger boxes for less money, or, in other words, using lighter weight linerboard. The kraft mills are naturally striving to manufacture stronger linerboards and run to narrower quality limits. Uniformity has long been associated with better efficiency, both in the mill and the box plant.

Table VII shows the results of two boards, 33 lb. and 38 lb., which were produced for high box strength evaluations. These boards are not commercially produceable at the present, although they were manufactured on conventional linerboard machines. The pulp was a special, high-strength pulp. These data are being presented to show what is being studied by the kraft mills for higher strength corrugated boxes.

High strength liners, more efficient and functional liners, more attractive liners, and the other specialty items previously mentioned are only a few of the areas where kraft linerboard is helping the fiber box meet the dynamic packaging requirements of the future. Since ours is an age of research and development, other areas of liner and box improvement will undoubtedly continue to appear. With the record of what kraft mills have accomplished in the past, it is certain that the kraft industry will do everything in its power to supply the boxmaker with the materials he needs to meet the challenge of modern packaging demands with confidence and success.

NOTES

1. Estimated to be 252,000 tons.
2. Although some virgin kraft linerboard is manufactured on cylinder machines, in the paperboard industry the term *kraft linerboard* refers to linerboard manufactured from virgin kraft fiber on fourdrinier type paper machines. That made on a cylinder machine is called *cylinder kraft.* In 1958 production of cylinder kraft amounted to 124,800 tons.
3. Association of American Railroads.
4. Principally linerboard, but some kraft corrugating medium is produced at this mill.
5. It also has come to be known as the kraft process.
6. Salt cake.
7. In 1958, 81.8% of the total kraft board produced in the United States was produced in the south, 16.8% on the West Coast, 1.4% in the north.
8. Some kraft mills use a small percentage of hardwood in linerboard furnish.
9. Excluding rag, flax, and synthetics because of economics.
10. Hardwoods are used primarily in the manufacture of corrugating medium and fine papers.
11. Furnish for a 100-lb. test board, 50 lb. basis weight.
12. Tear results on no. 1 grade wastepaper pulp is effected by low apparent density (or approximately 25% higher caliper) of this pulp. If adjusted for this property the tear test would be considerably lower. The stiffness is lower than on kraft in spite of the higher caliper.
13. Rule 41 specified 0.018 in. thickness for 100-lb. test liners from 1919 to 1925.
14. As the fibers were refined they matted down easier, forming a denser sheet which made it extremely difficult to maintain the caliper specified in rule 41.
15. The kraft paper supply greatly exceeded the demand and many kraft mills were operating at less than half capacity.
16. Some 0.030 in. was manufactured as 85 lb. per 1000 sq. ft.
17. The bulky 0.016 in., 42-lb. sheet—frequently spotty adhesion was encountered, principally on the double-backer, due to the rough, uneven (thick and thin) surface not making positive contact with the flutes.
18. (1) Up to 1937, 33 lb. was actually run to 36 lb.; up to 1941, 38 to 40 lb.; up to 1933, 47 to 50 lb.; up to 1944, 69 to 72 lb.
    (2) Prior to 1944 there was great discrepancy in the mullen test results obtained by various laboratories and even between individuals in the same laboratory. The FBKI commissioned the Institute of Paper Chemistry, Appleton, Wis., to study the mullen test. They found some testers as much as 30% out-of-agreement with each other. In 1946, the Institute published calibration and testing procedures that brought the mullen test in line, hence the dip. All major kraft producers now standardize their mullen instruments with the Institute of Paper Chemistry.
19. These sheets have almost completely replaced the clay-filled kraft. They are by far the most popular of the specialty linerboard grades, and many companies have adopted them for product identification or brand distinction.
20. For some time it was almost impossible to make mold-resistant linerboard on high-speed fourdrinier board machines except in large quantities and with production of twilight tonnage for which the box plant had to find special uses. Today, new techniques have enabled kraft mills to make mold-resistant board in considerably smaller quantities without producing the twilight tonnage.

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Resins and Coatings for Corrugated Board

H. N. JOHNSTON

Tracing the growth of corrugated board shows that its use increased some 450% in 20 years; from shipments of 21 billion square feet in 1935 to 93.5 billion square feet in 1955. Recent studies indicate that by 1965 shipment will exceed 130 billion square feet, or some 650% over the chosen base year of 1935.[1] Much of this growth can be attributed to the expansion of already existing markets because of increased population and improved economic conditions. For example, there are now more people with sufficient money to buy electrical appliances packaged in corrugated containers. However, the amazing growth of corrugated board has also occurred primarily because of the development of new uses and its penetration into areas formerly supplied by competitive materials. The development of moisture-resistant containers to replace wooden containers for shipping fresh produce is just one of a large number of corrugated products that illustrate this trend.

This past growth of the use of corrugated board, the current expansion of its use in many new areas, and the bright prospects for its future result in part from the use of resins and coatings to improve its properties. Combinations of corrugated board with resins or coatings has resulted in improved product quality, new products to replace competitive materials, and new uses and markets for existing corrugated products. In some instances, the use of resins and coatings

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[1] "Future for Corrugated Board," Leonard Guss, *Batelle Technical Review*, November, 1955.

with corrugated board has also resulted in savings in manufacturing costs and the reduction of certain problems during production or use of corrugated board.

By varying raw materials and processes and by the use of additives, the paper manufacturer can impart many desirable qualities and properties to paper during the papermaking operation. Among the most important qualities are wet strength, weight, brightness, smoothness, color, and porosity. However, by the use of various coatings, resins, and chemical treatments, the medium, liner, and the combined board can be made more useful and desirable for a variety of applications for which it would be unsuitable in the uncoated or untreated form.

A listing of the properties that can be imparted to corrugated board by various coatings and resins helps to explain why research and development of these products has created improved corrugated board and new markets. Through proper selection and application of coatings or resins, corrugated board can be made with improved resistance to moisture, gases, grease, water, and various chemicals. Other properties that can be imparted by coating or treating corrugated board are antislip qualities, abrasion resistance, release properties, improved smoothness, and antimarring characteristics.

The development of these added properties in corrugated board opened many markets formerly controlled by other packaging materials such as wood and metals.

Often the coatings applied to corrugated board are strictly decorative. However, even these decorative coatings must exhibit fair-to-good water and scuff resistance and good permanence of color so that the package does not become unsightly during storage or use. Because of these requirements, a combination of coatings is needed, such as a purely decorative coating plus an overprint coating to protect the decorative coating.

MATERIALS USED TO COAT CORRUGATED BOARD

Raw materials used to produce coated or treated corrugated board include most of the known resins or binders as well as pigments. The selection of material for a specific application, of course, depends upon the properties desired, cost, and possible methods of applications. Resins and binders used for this work can be broken down into three general categories, although some of the resinous materials may be available in two or all three forms. They are (1) water-dilutable materials (either emulsions or solutions in water), (2) hot melts, and (3) solvent-soluble materials. Of these three, the water-dilutable materials and the hot melts are the most desirable for the corrugated-board manufacturer. Since these materials do not contain organic solvents, they are usually less expensive than the solutions of the solvent-soluble materials, as well as less toxic and less of a fire hazard.

Many of the raw materials used are recent developments of the chemical industry. Among these are polyethylene, isocyanates, polystyrene, acrylics, polyvinyl acetate, and Werner complexes to mention but a few. Others are comparatively old materials, such as asphalt, wax, casein, starch, and natural gums, and oils which have, in some cases, been chemically modified to make them more useful.

The formulation of many of the coatings and treatments for corrugated board requires the combination of several resins or raw materials to produce a coating with the desired properties. Pigments such as clay, titanium dioxide, and calcium carbonate, a well as dyes and various toners, are used to produce white and colored coatings. Additives such as defoamers, wetting agents, flow agents, fungicidal agents, and antiblocking agents are sometimes necessary, depending upon the application and the binder.

SPECIFIC END USES

Probably one of the most widely discussed applications of resins to corrugated board is the impregnation or treatment of corrugating medium to produce improved strength properties under high humidity conditions. Quite a number of materials have been tried and used for this application, the most notable being sulfur, asphalt, rosin derivatives, phenolic derivatives, and hydrocarbon resins. All of these materials can be applied to the medium as hot melts but usually need some additive or modifier to reduce their melt viscosity so that they will penetrate the paper. Most of these materials can also be handled as water-dilutable products or in solvent systems.

Manufacturers have applied and are applying these treatments to the medium on coating machines as a separate operation, as well as an initial step before corrugation on the combiner. Other materials such as a chrome complex (stearato chromic chloride) and various latexes have been evaluated for treating the medium with varying degrees of success.

Medium treated with any one of these materials usually has much higher strength properties at 50% R.H. and 73°F. (normal conditioning atmosphere) than at higher humidity conditions. For instance, tests have shown that the addition of 5 to 7 lb. of a modified hydrocarbon-type resin to 26-lb. medium will about double its CMT (Concora Medium Test) value at normal conditions. However, at high humidity conditions there will be about a 40 to 50% fall off in CMT value (approximately the same percentage change obtained with untreated medium). Similar results were reported by H. S. Gardner.[2] Therefore, many corrugated-board manufacturers have found it more advantageous to use a heavier untreated medium, somewhere around 34 to 36 lb., to obtain nearly the strength properties obtained with 26-lb. treated medium. There are several other reasons for this approach. For example, untreated paper is usually easier to handle than treated paper on the corrugator and easier to bond with regular-type adhesives. Resin-treated sheets sometimes require special adhesives to obtain a good bond. Other factors favoring the use of heavier paper have been the integration of paper companies and corrugated converters and the surplus capacity of medium production in some areas in the last few years.

It should be recognized, however, that treatment of the medium does have advantages over the use of heavier, untreated paper in instances when (1) the methods and materials established by a company offer cost and quality advantages not obtainable by heavier untreated paper (because of long experience in treating the paper with equipment already available), (2) a shortage of medium makes it desirable to treat to satisfy a particular market, (3) there is a readily available low-cost treating material, and (4) there is customer preference for a treated-type container.

Closely allied to the treatment of corrugating medium is the over-all treatment of board as exemplified by moisture-resistant board and other similar products. Here waxes, resins, or combinations of both have been used to impregnate both the liners and the medium to produce a product that can be immersed in water and still maintain its functional properties. This development, in contrast to the treatment of medium, has opened up new markets for corrugated board, the most notable being shipping containers for perishable foods.

As in the case of raw materials for corrugated medium, cost and ease of application, which includes penetration into the board, are important factors in selecting impregnant. If the board must be bonded or printed after treatment, these factors must be considered. Also the toxicity, odor, and especially the carcinogenic properties of the material must be determined if the package will come in contact with food. Usually, low-molecular-weight materials having narrow melting ranges and low-melt viscosities are desirable and are generally modified with additives to further reduce the viscosity of the resins at elevated temperatures. Here again

[2] "Paper Reinforced Corrugating Medium on High-Humidity Containers," presented at the High Humidity Containers Session, Feb. 15–18, 1953.

waxes, rosin derivatives, sulfur, asphalt, and hydrocarbon resins play an important role.

Much work is still going on to define the parameters for the product in terms of production methods, materials, quantity, and location of the material in the board, and how these factors relate to strength, cost, and functional properties of the container.

Another relatively new corrugated product, which is closely related to over-all treatment of corrugated board in its functional properties, is board containing a foamed resin. Not only does the foam structure give additional strength properties under adverse conditions but also provides an insulating barrier. In other applications foam is used as a cushion in the shipment of delicate products. Resinous materials that foam are available in sheet, bead, and liquid form. Also available are prefoamed boards or sheets. Foams ranging from rigid through semirigid, to flexible with a wide variety of physical properties can be produced. Generally, these materials are produced by (1) the evolution of an inert gas which may be present because of having been previously dissolved in the uncured plastic mass, (2) the generation of gas by thermally sensitive materials evenly dispersed throughout the mass, and (3) the evolution of water vapor during condensation polymerization of the plastic.

Some of the more important types of foams that have been utilized in the corrugated industry are polystyrene and polyurethane foams. At the present time, because of their cost, foams usually must be used as multifunctional materials in the corrugated industry. A good example of this multifunctionality is in the shipping and storing of frozen foods. The foam board not only provides the necessary strength under refrigerated conditions but can also serve as insulated containers during delays the foods may encounter before they reach the customer. These unusual properties of foam combined with corrugated board offers the opportunity to penetrate markets now held by other products, especially because of their low weight and high strength characteristics. As formulations and techniques for handling are improved and as price declines, the growth of corrugated board combined with foam would appear to be certain.

The desire to use new methods and materials to package products such as furniture, highly finished hard goods, and sticky materials has brought about changes in the corrugated container. A number of these changes were concerned with the use of coatings to modify the surface of the liner to give it widely varying properties such as antislip, low frictional drag, antimar, and release properties or low adhesion to other materials.

Materials that have played an important part in these developments are waxes (both paraffin and microcrystalline), polyethylenes, hydrogenated oils (such as castor wax), silicones, colloidal silicas, and Werner-type complexes.

The fact that some liners mar highly finished wood surfaces and glossy metal enamels and that ordinary wax-coated liners cause "shining" or hard-to-remove wax marks during shipping has resulted in the evaluation and development of new types of coatings for many packaging applications. Not only do these packaging materials have to have the desired properties of antimar, but they must not react with the enamels and various finishes they contact during shipping at both normal and elevated temperatures. Castor wax, polyethylene, and combinations of microwaxes and paraffin (used by themselves or modified with silicones or other well-known slip agents such as stearic acid) are some of the more common materials available for formulating satisfactory antimar coatings. Coatings formulated with these materials can be applied by conventional paraffin coaters. These coatings tie down the rough fibers of the liner and act as dry lubricants during the shipping of the product.

Another similar packaging application is the use of coated liner board to facilitate the shipping of sticky products such as camel-back rubber. Many conventional-type coatings such as varnishes or lacquers can be adapted for this purpose by merely incorporating a small amount of release agent into the coating. Silicones, mineral oils, and various waxes have all been found useful as release agents. A chrome complex (stearato chromic chloride) has also been used in instances where a surface with good release characteristics is desired.

The other two types of coatings that have been applied to corrugated board because of materials handling problems are nonslip coatings and low-frictional-drag coatings. Nonslip coatings are probably best illustrated by materials containing colloidal silica. Silicas, which have been widely used in nonslip floor polishes, have also found wide acceptance in the corrugated field. These products when incorporated into a coating vehicle cause a roughened surface and impart a nonslip surface to the container. A different mechanism is employed when a wax or resinous coating containing a sticky rubber or special wax is incorporated to give the board a nonslip property.

The reduction of frictional drag between paper and surfaces it contacts is extremely important when automatic equipment is used during the packaging operation. By applying thin films of drag-reducing agents to wax-coated board, the frictional drag between the paper and the surface in contact with it is no longer a problem. Also scuffing of the coated surface is reduced. Materials that have been evaluated and found successful for this purpose include emulsions of cottonseed oil and mineral oil and solutions of polyethylene glycols. It also appears that these same materials might be of value in reducing the marring properties of paraffin-coated board. However, this would result in a two-coat system on the board.

The increasing response of corrugated containers to the demands of retail outlets has also resulted in the use of more decorative as well as functional types of coatings. To meet the need for packages that can be examined closely by the public, the manufacturers of corrugated boxes have created containers attractively designed and printed. These containers required coatings to produce (1) an over-all color coating or patterned coating on board, (2) a smoother surface for better printing and better "mileage" of expensive inks, and (3) protection of the color or patterned base coating from rubbing, water, high humidity, dirt, snow, abrasion, and other factors encountered during its service life.

Over-all coatings or color-coating of board usually employ one of several types of water soluble materials such as casein, alpha protein, or starch. However, in addition to these "old standbys," there are available to the formulator a number of new synthetic latexes that have been marketed in the last few years. These are styrene-butadiene, polyvinyl acetate, and acrylic emulsions. While these three polymers occupy a very favorable position in the paper coating field, other vehicles such as polystyrene, polyethylene, alkyds, hydrocarbon resins, and even lacquer-type emulsions are being used by themselves or in conjunction with other emulsions.

Because of their relatively high cost, as well as their thermoplastic properties, many of these polymers are used as modifiers to improve the flexibility, waterproofness, and gloss of coatings based on casein, protein, or starch. A typical overprint coating might contain casein or protein, styrene-butadiene emulsion, clay, and other pigments such as titanium dioxide, an alkali to dissolve the casein and an insolubilizing agent. Other additives to control flow, viscosity, foaming, and blocking may be necessary.

Sizing or primer coating of liner board can result in (1) improved printing quality because of improved smoothness of the board, (2) reduced consumption of ink and higher ink gloss because of decreased penetration, and (3) decreased consumption of lacquer, varnish, or wax overprint materials. This type of functional coating is gaining use in a wide variety of fields not only because of superior properties, but often because it permits improved economy even in the face of ini-

tially higher cost of the board. Sodium silicate, water-soluble fluorochemicals, carboxymethylcellulose, and ethylated starches, as well as many of the aforementioned emulsion polymers serve as priming coats before the application of a more expensive secondary material. These coatings are not only valuable for this particular purpose but could also be important in the reducing of the amount of waxes, polyethylene, and other coatings discussed in the earlier part of this paper. Some converters, with their own mills, have found it advantageous to make a specially sized board for uses that require coatings during the converting operation.

Overprint coatings, to protect the container as well as the printing, have become more important in recent years when the box becomes not only a salesman but a re-usable container in some instances. Clear coatings applied from solvent, emulsion, and hot melt systems are available. Again, acrylic, polyvinyl acetate, lacquers, and varnish lead the list of materials that are applicable from solvent and emulsion systems. Good water resistance, clarity, gloss, block resistance, abrasion resistance, adhesion to ink and paper, and fast dry are obtainable with these products by proper formulation and additives. Hot melts of paraffin, microcrystalline waxes, and polyethylene are also suitable for this application.

COATING OF CORRUGATED PAPER

The coating or treatment of corrugated paper can be accomplished before, during, or after corrugation. The method and point of application depends on the coating and, of course, the equipment available at the particular plant. Many types and variations of roll coaters are in use, designed especially for a specific job such as color coating of liner, paraffin coating of board, and application of resins to medium. Frequently, heated drums and drying ovens are used as auxiliary equipment to speed the operation. Also during the coating operation, a metal film or plastic film can be laminated to the substrate with the coating acting as an adhesive. Coatings can also be applied during the printer-slotter operation by a printing-type process.

In addition to these more conventional-type coating methods, a number of new processes and pieces of equipment are now being used or are available to the corrugated converter for new or improved coating systems. Among these are the curtain or veil coater that applies an even film to rough, uneven surfaces; pressure and hot-spray units for application of waxes, resins, and high-solids coatings; catalytic spray guns for the spraying of foams on specific areas, electrostatic coaters for the deposition of pulverized coatings and resins, and, of course, extruding units for the application of polyethylenes and similar materials.

THE FUTURE OF COATINGS IN CORRUGATED BOARD

Unquestionably, the volume of coated and treated corrugated board is increasing. Today, much research in polymers, pigments, waxes, and other related aspects of coating technology is being directed toward the development of new or improved materials for the paint and paper industry. Other investigators are working along fundamental lines to add to man's knowledge of the factors affecting the performance of coatings. Still others are working less directly in the development of coatings by conducting research to find new uses of chemicals or by-products in coatings.

However, many of the technologists working in these fields are unaware of the coating problems encountered in the corrugated board industry. Making them aware of the problems of coating corrugated board, as well as obtaining their know-how and information can, no doubt, lead to new gains in this area. Some coating suppliers are developing their technology to broaden their markets into the corrugated field.

On the other side of the picture, some corrugators are now hiring or contracting the "know-how" of resin and coating technologists to improve their position in this expanding field of coatings for corrugated board. These men are able to contribute valuable know-how, both from their resin background and their knowledge of the new methods for applying coatings that have been developed in the paint industry.

About the only thing in the corrugated field that seems permanent is *change*. Changes in merchandizing, packaging equipment, requirements for corrugated containers, adhesives, and equipment in the corrugating plant indicate the use of more and an even greater variety of coatings and resins in the corrugating industry. Such products as flame-retardant coating, vapor-phase-inhibitor coatings, flock-decorated containers, and coatings for carrying or duplicating messages to facilitate automatic handling of the container might all be in the future for the corrugated industry.

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Waste Improvements Through Engineering

C. B. LAWLER

Before reviewing some of the ways engineering can contribute to the reduction of waste in a corrugated box plant, I would like to define the word *waste* as used in the title of this paper. Waste, in this case, is that part of all board consumed in the manufacture and delivery of corrugated packaging that is either not satisfactory, or not required, as part of the finished product accepted by the customer. Some waste, of course, is required in the manufacture process such as cut-outs of slots and die cuts. Other waste is needed as "insurance" to cover recognized variations related to the material, the machine, and the operator. Additional waste results from carelessness or mistakes in judgment. A final category includes excessive material hidden in the finished product, such as excessive draw of corrugated medium and up-graded liner. This last group is not customarily reflected by reports of waste percentages which are based on baled waste. However, it represents an expensive type of waste, since it is "given away" without being credited for waste value.

It may be of general interest to this group to take a brief look at what waste amounts to for the corrugated industry, and the trend for the last few years. Several factors have developed during the past few years that would be expected to have an adverse effect on waste, unless offset by efforts of the industry. Apparently, an increasing buyer's market has reduced average length of run and, to some degree, lead time, i.e., time to make delivery, both of which would have an unfavorable effect on waste. Also, unfavorable from a waste viewpoint have been demands in many cases for above average quality, special applications such as tear tape and nonskid, an increase in specialties, multicolor printing, and others. Last, and far from being minor, has been the increasing need for productivity gains, which reportedly have not opened the narrowing gap between increasing labor rates and box prices. This could mean a tendency to incur more waste in return for a higher speed.

All of this would lead one to believe that waste could have been increasing in the industry, although from the available data, this does not appear to be the case. Unfortunately, only a limited amount of information was available on average gross baled waste. This is occasionally determined from surveys by various organizations including TAPPI. The most recent was a survey made in 1955 by *Fibre Containers*, which reported a total figure of 10.8% for the three months covered. Although published data on the industry's waste trend appears to be practically nonexistent, I believe we can

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get a broad picture of this by reviewing annual shipments of combined board products versus roll stock consumed, as reported by the Fibre Box Association. Changes in the ratio of square footage shipped, per ton of roll stock used, should give a general indication of the overall waste trend. These ratios of output to consumption for the past five years are as follows:

Year	*Board consumed (million tons)*	*Shipments (billion sq. ft.)*	*Ratio (M sq. ft./ton)*
1954	5.95	81.41	13.7
1955	6.76	93.32	13.8
1956	6.91	96.00	13.9
1957	6.89	95.76	13.9
1958	6.85	96.01	14.0

The increasing ratio indicates a trend to greater square footage shipped per ton of roll stock consumed. A change in average basis weight may have been a factor in this trend, but I believe we can conclude that during this period, the industry has been holding down its waste line and possibly showing a slight improvement.

Undoubtedly, if we take a careful look at our own plant waste, very few of us would feel that it is as low as it should be, or close to an irreducible minimum. Much has been said about waste being a subtle, but potent, drain on profits. Also, that it is probably one of the largest reducible costs in corrugated box plants today. Certainly, this is very true in a great many cases. However, I would like to point out here that, if the major factors of box plant operation are ranked, fulfilling delivery and quality requirements would be followed by productivity and waste in an economical balance.

It seems to be a general practice to occasionally figure annual savings that would be realized if plant or gross waste is cut 1%. Invariably the result is very impressive. Then comes the question of how to get this 1%, or more, as the case may be. This is where considerable difference of opinion exists. Some have made up manuals of *do's* and *dont's* covering many work habits throughout the plant that affect waste. Often waste reduction drives or compaigns utilizing posters and displays are used, and, if properly carried out, they at least get across the point to everyone that waste is important. However, any reduction in waste is usually temporary, as it is difficult to get sustained interest and action through this approach.

How can we get waste to a desirable minimum and keep it there, without reducing service, quality, or productivity? There is no simple formula. The answer lies in continuously striving for improvement in all of these areas:

1. Facilities, including machines, layout, and handling equipment.
2. Production planning, from roll stock inventory to the customer.
3. Quality of roll stock, combined board, and finished boxes.
4. Operating methods or practices.
5. Supervision and operating personnel development.

Of course, improvement in these areas will obviously result in many other benefits, in addition to a lasting reduction of unnecessary waste. Admittedly, this is a rather broad and sizable objective, and in our company, engineering personnel are utilized to assist in all of these areas to varying degrees. In our Corrugated Division this covers the general fields of industrial engineering, quality control and mechanical or plant engineering.

Also, there have been a great many significant developments of an engineering nature made throughout the industry and by its various suppliers. Many of these developments have made considerable contributions to improving quality and minimizing waste, or the cost of waste.

It would be impossible to review anything more than some typical examples of engineering advances, contributing to the reduction of waste. I would like to begin with some examples of work done by our engineering personnel in this field. Before I start, let me point out that engineering, as such, is based upon facts and data, and when we talk about an *engineering approach*, this is what we mean.

Engineering Economic Studies of machinery or material handling equipment, play a large part in additions, replacements, modifications, or major overhauls. The analysis includes costs, advantages, dollar savings, and other benefits. Often savings from waste reduction are a very significant factor in these studies.

Preventive Maintenance programs definitely play an important role in waste reduction, particularly on the corrugator. Scheduled reviews are made on all critical parts of major machinery. These reviews involve engineering and maintenance personnel, the plant superintendent, and department foremen. Also, maintenance work is done and inspections made on an established frequency.

Training is an excellent approach to waste reduction, as well as a generally improved operation. To outline briefly our box plant program, we have a training committee consisting basically of the plant manager, plant engineer, superintendent, personnel manager, plant accountant, and department foremen. Possible subjects are screened by the committee, and a specifically defined subject is assigned to a shift foreman. He, in turn, prepares the training talk, which he first presents to the committee for suggested improvements and approval. He then personally presents it to all people in his department who would benefit from the particular subject covered. To develop a write-up of the proper method, often utilizing photographs or drawings, he is assisted by engineering and personnel. Reference to manuals and blueprints from the machinery manufacturers and other engineering information is often helpful in this regard. A few examples of subjects covered are: "Setting Corrugator Glue Roll Clearances"; "Setting and Running Tear Tape"; "Setting and Running Nonskid Solutions"; and "Corrugator Offbearer's Board Inspection Procedure." Not only do the operating personnel receive direct job training, but everyone involved in the procedure adds to their knowledge of box plant operations. Often, improvements to the machines and methods are brought out by this approach. This is a continuing program and has proved to be very beneficial.

Quality Control, including inspection procedures, is an engineering responsibility. Briefly, inspections are made continuously at the delivery end of the corrugator, and on a frequent sampling basis in all other operations. Defects are reported according to defect specifications which are, in effect, quality tolerances. While quality performance remains unquestionably a responsibility of the Operator and Foreman, the Inspectors frequently catch defects at an early stage, thus eliminating or minimizing waste. Also, posting of the inspec-

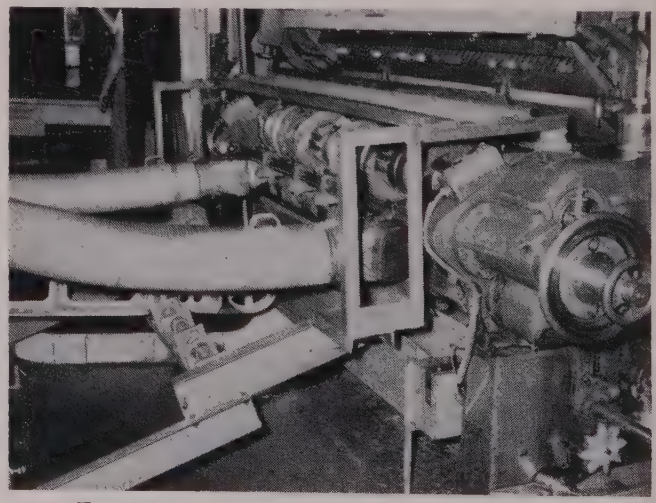

Fig. 1. Printer-slotter waste disposal system

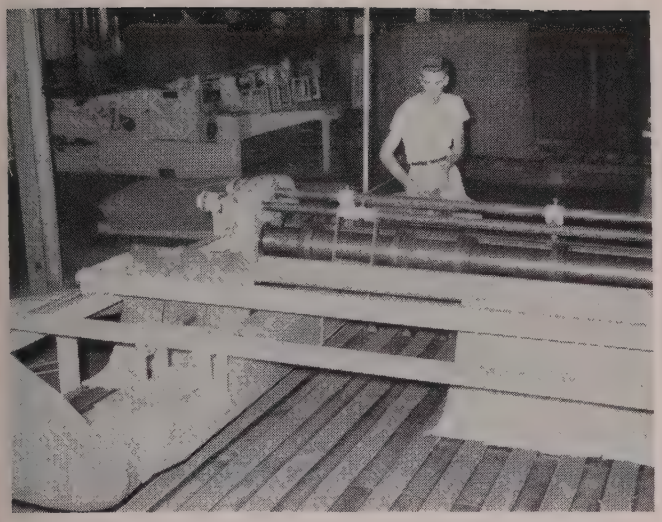

Fig. 2. Rapid slitter waste disposal system

tion results by operator at each machine has the effect of increasing the quality performance and reducing waste.

Pneumatic Waste Conveying systems, to reduce the cost of waste handling and to conserve floor space, have been engineered for practically all cutting operations, including the corrugator, printer-slotters, die cutter, flap cutter, saws, partition slotter, slitters and folder-gluer. As part of the installation of sheet stackers on our printer-slotters, we installed blower systems on individual presses to automatically remove all trim. Figure 1 shows this arrangement on the delivery side of a printer-slotter. Side ducts are used for trim and stitch tab cut-outs. A hopper, with tapered sides and bottom, leading to a duct, continuously removes slot cutouts. This installation contributes considerably to an efficient sheet stacker operation by reducing interference from trim waste. In changing from a three-man to a two-man crew, run speeds more than offset an increase in setup and wash-up time. In addition to a labor saving, by eliminating the time required for handling trim waste, the operator has more time to insure good quality and, thereby, eliminate waste.

Figure 2 shows a similar type system with modifications to adapt it to a hand slitter. This requires either a right angle takeoff, or a straight-away delivery as used here, so that trim ducts will not interfere with offbearing. Narrow trim is handled on one side and wide trim on the other. This system not only improves waste handling and floor space utilization, but facilitates offbearing by eliminating trim tangling in the sheets.

Special Waste Surveys have been made at times by our industrial engineers to determine accurately the waste source, specific cause, and the amount. The waste breakdown in Table I was based on such a study. Probably one of the most comprehensive of its type, this survey was made at our Savannah box plant five years ago, at which time the waste was considered to be too high. Twelve engineers, temporarily available during a mill maintenance shutdown, covered all departments around the clock for four days.

The most interesting point about this study was that, when all causes were accurately identified and charged back to the source, the corrugator total was 8.22%, or 93%, of all controllable waste. Item 1, sheet waste, was by far the largest single category after being charged with all sheets rejected in following operations due to combining defects. Item 2, side trim, indicates that the actual total of 2.20% was higher than the calculated amount of 1.75%, based on the schedule. This was caused by the crews running out butt rolls and occasionally running a roll wider than specified. End trim on the sheet length, although calculated at 0.54% based on scheduled trim allowances used by planning, was actually 0.89%, due to the addition of an average of $^1/_4$ in. to the sheet length by the

Table I. Comprehensive Waste Breakdown by Source; Gross (Total Plant Waste)—10.53%

		%	%
I.	Controllable (net waste)		*8.82*
	A. Combining		*8.22*
	1. Sheet Waste[a]		4.29
	a. Rejected at corrugator	2.76	
	b. Rejected at presses and sundry cutting	1.14	
	c. Rejected at finishing	0.39	
	2. Side Trim		2.20
	a. Scheduled (calculated)	1.75	
	b. Additional (i.e., studies)	0.45	
	3. End Trim		0.89
	a. Scheduled (calculated)	0.54	
	b. Additional (sample measurements)	0.35	
	4. Butt rolls (incl. core)		0.33
	5. Strip		0.33
	6. Bridge (single face)		0.18
	B. Fabricating[b]		0.60
	1. Press and Sundry Cutting		0.48
	a. Spoilage	0.28	
	b. Rejected at finishing	0.20	
	2. Finishing Spoilage		0.12
II.	Noncontrollable		
	A. Customer's Waste (calculated; includes cutouts for slots, stitch and glue tab, die cuts, flap cuts, corner cuts, etc.)		1.71

[a] For breakdown by reason, see Table I-A.
[b] For breakdown by reason, see Table I-B.
Note: Unless otherwise noted, amounts are based on actual weight.

Table I-A. Sheet Waste Breakdown

A. Corrugator Sheet Waste Rejected at End of Corrugator — 2.76% Gross waste

Waste Reason	*% of A*
1. Misaligned	41.2
2. Loose liner	34.7
3. Splice	11.6
4. Fractured corrugation	3.8
5. Blistered liner	3.5
6. Short sheet	1.3
7. Adhesive run over or dry	1.1
8. Machine jam	0.7
9. Samples-quality control	0.6
10. Damaged liner	0.4
11. Paper break	0.1
12. Warped	0.1
13. Other	0.9
	100.0

B. Corrugator Sheet Waste Rejected at Presses and Sundry Cutting — 1.14% Gross waste

Waste Reason	*% of B*
1. Loose liner	33.4
2. Short sheet	24.8
3. Wet board	12.6
4. Cut scores	8.7
5. Warped	7.6
6. Misaligned	5.2
7. Blistered liner	4.7
8. Wrinkles	3.0
	100.0

C. Corrugator Sheet Waste Rejected at Finishing — 0.39% Gross waste

Waste Reason	*% of C*
1. Loose liner	83.5
2. Short sheet	8.3
3. Oil spots	4.4
4. Excess adhesive	1.8
5. Other	2.0
	100.0

crew. Butt rolls (including cores), strip waste and bridge, or single face waste, were relatively small. Under fabricating waste, press and sundry cutting increased from 0.28 to 0.48% after being charged with press waste rejected in finishing. Net finishing waste was only 0.12% during the 4-day period. Noncontrollable, in this case consisting only of customer's waste, was 1.71%.

Table I-B. Fabricating Waste Breakdown

I.	Presses and Sundry Cutting		0.48% Gross waste
	A. Spoilage		0.28% Gross waste
	Waste Reason	*% of A*	
	1. Press waste, general	38.5	
	2. Setup	18.3	
	3. Pallet damage (handling)	17.7	
	4. Printing	17.6	
	5. Other	7.9	
		100.0	
	B. Press Waste Rejected at Finishing		0.20% Gross waste
	Waste Reason	*% of B*	
	1. Slot out of line	39.2	
	2. Print smeared	24.1	
	3. Score too deep	24.1	
	4. Other	12.6	
		100.0	
II.	Finishing Spoilage		0.12% Gross waste
	A. Net Finishing Waste		0.12% Gross waste
	Waste Reason	*% of A*	
	1. Machine jam	50.7	
	2. Torn liner	41.8	
	3. Machine adjustment	1.4	
	4. Other	6.1	
		100.0	

Table I-A shows a detailed breakdown of the reasons for sheet waste. Loose liner, misaligned, short sheets, and splices were by far the largest causes.

Table I-B shows a breakdown of the reasons for fabricating waste. Engineering studies of this type help point out specific areas which require corrective action.

In view of the importance of the corrugator as the primary source of controllable waste, I would like to review a few specific examples, from roll inventory through the cutoff knife, of the many engineering contributions in this area.

Roll Storage and handling is quite a large factor in scheduling and servicing a corrugator efficiently for minimum waste. High stacking roll grab trucks, now used in a number of plants for vertical storage ,result in greater utilization of cubic space and better selectivity of grades and sizes. This, combined with a well-defined storage layout, tied in with a good inventory control system, can directly affect side trim, upgrading and number of change-overs scheduled on the corrugator.

Starch Mixing procedure, including viscosity and temperature control are responsibilities of our engineering personnel. This, of course, is very important to quality and waste and, therefore, should be constantly controlled.

Cutoff Counters for our corrugators were designed and manufactured by Production Instrument Co. of Chicago to accurately control sheet count produced. Figure 3 shows this electrical counter, called the Monitor Counter, at our Trenton, N. J., plant. Briefly, the device functions this way. While counting on the order being run, the desired total count for the next run is set at the top. The *alert* setting is then entered on the middle row, with sheet counts approximately equal to 500 lineal feet. During the next run, this will sound three blasts on a horn to signal the single face operator to make his change-over at a point where approximately 500 ft. remain to be run through the cutoff. The *action* setting, normally about 50, is entered on the bottom row. This will sound two

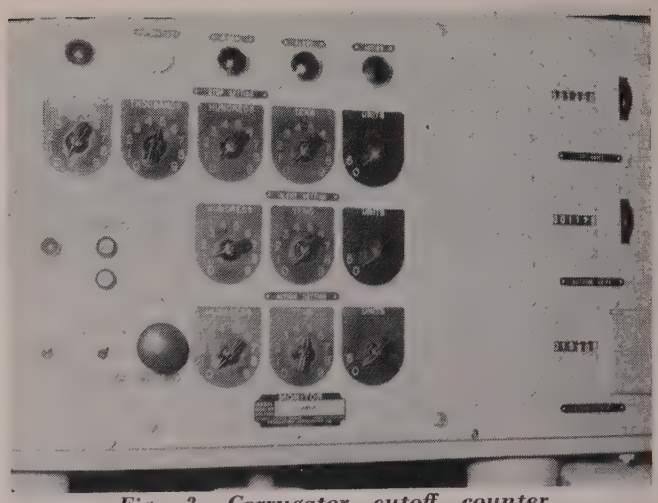

Fig. 3. Corrugator cutoff counter

blasts to signal the crew when 50 cuts remain on the order. The automatic-manual switch is normally left on *automatic* to stop the double facer at the final count. At the start of the next run, the *reset* button is pressed which starts the counter on the new settings and cancels the previous ones. The Monitor Counter has not only been of great assistance in minimizing overruns and underruns, but has relieved the slitterman of unnecessary count checks, so that he has more time available for setups and inspection of quality, including sheet length. In addition, this installation has proved to be very reliable.

Web Alignment problems represented the largest single source of waste in the waste study data shown in Table I, when both side trim and rejected sheets due to misalignment are collectively considered. Total Side Trim was 2.20%, including 0.45% excess, or not scheduled. The total for rejected sheets due to misalignment was 1.73%. No doubt, much of this was caused by operator error, although, at the time of the study, both corrugators in this plant were equipped with shaft type roll stands. Since that time, new, shaftless, roll stands were installed on one corrugator, definitely producing a favorable effect on waste. However, detailed data are not currently available on misaligned sheet waste. In addition to easier roll alignment, these shaftless roll stands contributed directly to better quality, and consequently less waste, by considerably improved braking, or tension control. Less waste also results from reducing the problem of split cores, which previously was excessive due to chuck tightening on the old stands.

For further reductions in side trim, several makes of web alignment systems are available which are reportedly designed for close alignment throughout the corrugator, covering medium, liner, and single face webs, and the slitter. We have had no direct experience with the operation of this equipment. However, we have had discussions with the manufacturers and have studied the possibilities of waste savings. Assuming the equipment will maintain alignment at all stations within ± 0.015 in. as guaranteed by the manufacturer, waste savings would be realized by eliminating sheet waste due to misalignment, and also by reducing the side trim required. Basically, a certain amount of side trim is necessary to allow for (1) the weaving of the individual sheets and combined board, (2) the width shrinkage of the board caused by steam, hot plates and preheaters, and (3) sufficient trim for a clean, straight slit of the combined board at the triplex slitter. To cover these, we use a minimum allowance for single wall of $^3/_4$ in. over-all, or $^3/_8$ in. per side. The allowance used for double wall is 1 in., or $^1/_2$ in. per side.

Due to shrinkage and scheduling problems, some trim would still be required with this type of alignment system. However, we believe the minimum side trim allowances could be reduced by $^1/_4$ in. if the practice of trimming both sides is

continued. If the relative settings of the alignment devices can be made accurately, there may be some cases where trim would be taken only on one side. In this case, an additional 1/4 in. of side trim would be saved. A slight misalignment would have to be tolerated on the untrimmed side.

Assuming an average trim reduction of 3/8 in., annual savings would be approximately $12,700 on the production of 36 million square feet per month, with an average roll width of 72 in. and an average combined board basis weight of 130 lb. This example assumes the reduction will be in the form of less tons of roll stock consumed and is based on the 1958 average market price of board at $123 per ton, less baled waste credit, reduced for baling and handling costs, of $35 per ton. This savings would be increased somewhat by a reduction in the amount of sheets rejected due to misalignment that are not salvaged. This, of course, would have to be determined for the particular plant involved. Another approach to reducing side trim by controlling slitter alignment will be covered in the next paper to be presented.

Single Facer design has been improved in numerous ways during the past few years. Some of these include devices for more accurate and simplified setting of glue and doctor roll, pneumatic or hydraulic pressure and corrugator roll loading and tapered speed glue roll drives. All of these make it easier for an Operator to consistently produce quality single face and less defective material. Many of these devices have been installed on existing machines.

Draw or Takeup Factor of Corrugating Rolls, if excessive, will consume an unnecessary amount of medium, and can definitely be a source of waste in corrugated box plants. There are a great many factors that effect draw and I will limit my comments to a few points concerning the waste economics involved.

Draw, of course, refers to the amount of medium consumed per the amount of liner consumed, expressed as a ratio. Our engineering personnel make periodical checks to determine the actual draw factors by flutes, based on actual measurement of lineal footage of medium and liner going into the single facer. We maintain records of this data so that the trends of performance variations due, for example, to wear, refinished or recut rolls and roll replacements, can be followed.

It is difficult to define clearly the amount of excessive draw but, in general, it refers to the consumption of more medium than is needed to produce the desired combined board quality. A slight reduction of draw factor can produce a sizable savings in medium. For example, assuming the total production of 36 million square feet per month with an average draw factor of 1.500, a reduction to 1.485, or 1%, would reduce annual medium consumption by $11,500, at the present market price of $1.72 per 1000 sq. ft. for semichemical. From this example, the importance of the effect of draw factors on board consumption can be seen.

For a given set of corrugating rolls, wear will tend to reduce draw factor, although quality, of course, will also decline. Refinishing can usually be done with little or no effect on the draw factor. Recutting, which reduces the roll diameter and thereby tends to increase draw, is usually offset by a modified flute contour design.

The subject of flute contour design for a number of years has received considerable study and research by the box industry, machinery firms and others. The results of much of this work have been presented at these TAPPI meetings. Improvements in design are directed toward improving single face quality and runability, or speed, and at the same time reducing the draw factor. As a result, corrugating rolls being made today offer considerable savings in medium consumption. One particular example of above-average draw reduction is the 39 flutes-per-foot "C" flute rolls, reduced from the conventional 42. Based on the designed draw factors for these rolls, the theoretical reduction is a little over 2%, which would save approximately $23,000 per year in medium consumption, under similar conditions as mentioned in the example above. Research and design are continuing in the area of flute contour design and no doubt additional improvements can be anticipated.

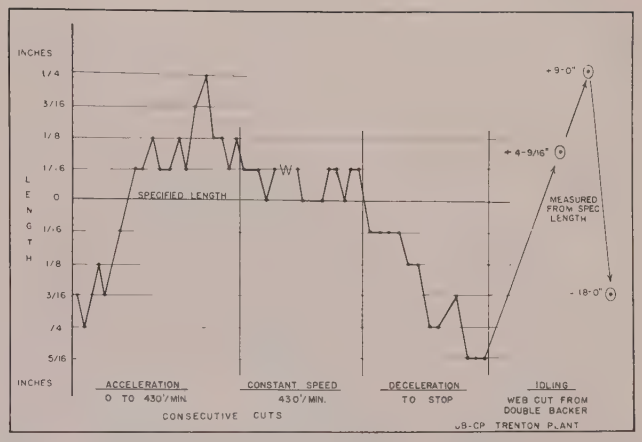

Fig. 4. Cutoff variations accelerating and decelerating (typical)

Glue Machine and Double Facer design improvements have been added to many machines. The results of the waste study shown in Tables I and I-A indicate that loose liner was one of the major categories of waste, and although we did not separate this into categories of inside and outside liners, no doubt more than half of it originated at the glue machine and double facer. Devices such as the tapered glue roll speed drive have contributed to better glue applications at all speeds and thus have contributed to the reduction of sheet waste due to loose liner. Also, rider roll positioning and adjustments have been refined to facilitate their proper setting for more accurate and consistent adhesive application. A number of other refinements such as simplified belt tension adjustment, both top and bottom, and automatic belt lift during downtime have contributed to a better operation and less scrap.

Corrugator Cutoffs are a source of considerable waste and substandard quality in most plants. Variations in length of cut result in both excessive sheet length and short sheet rejections. Gap variation at the manufacturer's joint is not only the result of scoring and folding variations, but is frequently caused by inaccurate cutoffs. For these reasons, cutoff design has been, and is continuing to be, an area of considerable engineering effort by machinery manufacturers.

Before outlining some of the work being done in this direction, I would like to review briefly some of the causes of error in conventional rotary cutoff operations. These can be grouped basically into three categories, (1) web advance variations caused by slippage in the double facer, (2) cutoff knife inaccuracies inherent in the basic design, and (3) errors

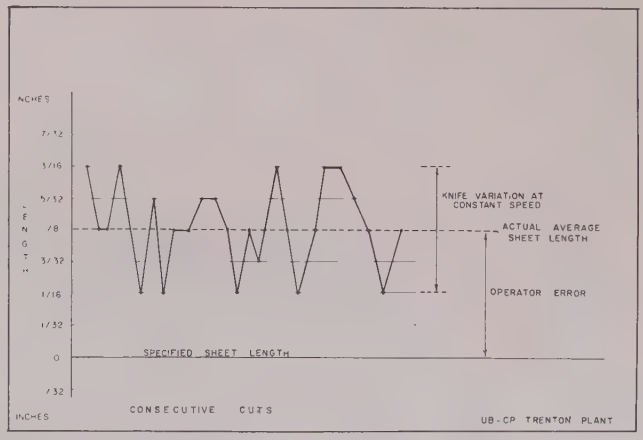

Fig. 5. Cutoff variations constant speed—475 f.p.m. (typical)

in operator setting. Excessive roll stand brake tension and friction between board and hot plates can cause slippage, either at the belt drive pulley or between the belts and board liners. These causes of variation in web advance can, in most cases, be eliminated by adequate maintenance and careful operation. Error inherent in the design of variable speed drives used in conventional cutoffs causes most of the variation in the knife itself, usually magnified during acceleration and deceleration of the corrugator. This can be accentuated by the lack of adequate maintenance. This design also complicates a machine scale setting of length by the operator. To get a fairly accurate setting, he must measure the sheet and jog the setting usually one or more times.

To get an accurate picture of actual cutoff variations, a series of consecutively cut sheets were measured and recorded at one of our plants. Figure 4 is typical of the studies made during acceleration and deceleration of the corrugator. This machine is approximately ten years old, and the length had been set slightly above the specified length, previous to this cycle. These variations, as much as $^5/_{16}$ in. short when decelerating in this case, show the adverse effect of speed changes on sheet length. The last three cuts were made while idling the cutoff after the web was severed from the double facer at the hand shear. The whole sheets of this tail end are cut as much as 9 in. too long, and are usually rejected. This represents a constant source of waste on each slitter change in proportion to the distance from the hand shear to the cutoff knife.

Figure 5 covering a range of $\pm^1/_{16}$ in. is typical of knife variation at constant speed on which a number of studies were made. In this example, the setting or operator error which represents excessive end trim, averaged $^1/_8$ in. longer than the specified length. These studies, limited to lengths up to 86 in., did not indicate any effect of sheet length on the amount of variation.

In order to minimize cutoff variations, machinery manufacturers have taken several approaches. One new type of cutoff, which has been in operation for some time, provides greatly improved method of operator setting which permits accurate preselection of length. A maximum variation of all speeds of $\pm^1/_{32}$ in. reported by the manufacturer is achieved through flywheel balancing to eliminate cyclic surges from the crank mechanism, and electrical measurement and control of error in the variable speed drive, in this case, a PIV. Other machinery manufacturers have designs in process or experimentation to detect and control variations due to variable speed drives and web advance speed, relative to knife speed. Also, simplified and accurate operator setting, as well as a photoelectric eye for register control of preprinted liner are objectives in this work. These are intended as attachments to existing conventional cutoffs. In one instance, a conventional cutoff is being built, modified to include an additional crank linkage to improve balance.

No doubt, cutoff knives such as this will improve quality and reduce waste. However, the utilization of this equipment and the probable economics of waste savings from it, would vary considerably from plant to plant depending on the average sheet length run, end trim standard allowances, excessive end trim (which is often mixed in waste blower systems with side trim), sheet waste due to length variations, quality standards and other factors.

Sheets rejected due to short lengths would certainly be minimized. Using, for example, a figure derived from the waste survey discussed above, waste would be reduced approximately 0.35% for this reason alone. This would save $8500 annually in board consumption under the same conditions as used previously for a monthly production of 36 million square feet. Excessive end trim, or operator error in knife setting, if eliminated, would save an additional 0.35%, or a combined total of $17,000 annually. Further savings through reducing standard end trim allowances would be possible. We currently use a standard of $^1/_4$ in for stitched boxes, which are trimmed on one side at the press. One-half inch is allowed for taped boxes, trimmed both sides. These allowances are included to cover cutoff variations and to provide an adequate minimum press trim of $^1/_8$ in. Assuming a maximum cutoff tolerance of $\pm^1/_{32}$ in., the stitched box allowance of $^1/_4$ in. could be reduced to $^3/_{16}$ in. and the taped allowance from $^1/_2$ to $^3/_8$ in. This would maintain a minimum of $^1/_8$-in. trim for the press. Standard or scheduled end trim would be reduced from 0.54% to approximately 0.41 to 0.13% less waste. This would be valued at $3160 per year. Total savings then would be $20,160 annually.

While "no trim" runs might be made where quality tolerance would permit, trim would still be required in many cases. For example, our standard range for "B" or "C" flute taped box gap at the manufacturer's joint is $^1/_{16}$ to $^3/_{16}$ in. or a $^1/_8$ in. tolerance. It is not likely that this standard could be met when all sources of variations are considered. These include sheet shrinkage after leaving the corrugator, press hopper side clearance and alignment with slotter heads, and normal folding. While trim would still be required in many cases to insure a desired quality level, through the elimination of a number of sheet length errors due to speed changes and slippage in the double facer, a more consistent finished box quality would be attained.

Before concluding, I would like to add that there are a considerable number of ways engineering can help minimize waste in all box plant operations. Good layout and materials handling can reduce excessive handling and the possibility of "losing" loads during fabricating operations or when shipped. Handling systems engineered for specific operating needs and types of product will reduce load damage between operations. Printer-slotter score profile design for consistent folding is a critical area in quality and waste control. There are many others.

In conclusion, engineering of all types and interests relating to the corrugated box industry can be a tremendous influence in attaining a lasting reduction of waste, not only through the design of machines, layout, and handling equipment, but by providing specific information and recommendations to assist management in making important decisions concerning box plant facilities and operation. I am certain the future will see an even greater utilization of engineering in our industry.

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Corrugating Variables and the Effect on Combined Board Characteristics

R. C. McKEE

In the manufacture of corrugated board, the medium is subjected to a variety of stresses and strains particularly during its passage through the labyrinth of the corrugating rolls. The application of the stresses takes place at rather high rates of speed or frequency. In some ways it is surprising that a medium can withstand these effects. For example, at a nominal corrugator speed of 450 f.p.m., flutes are being formed at the rate of approximately 270 flutes per second in the case of A-flute and 390 for B-flute.

It is well established that corrugating mediums vary quite widely in their ability to corrugate without malformation of flutes even on a given corrugator. It has often been said that the quality of corrugated board is determined on the single-facer because it is here that the operation should develop the maximum potential of the medium. How complex the single-facer operation is may be indicated by considering that there are many variables associated with the single-facer operation.

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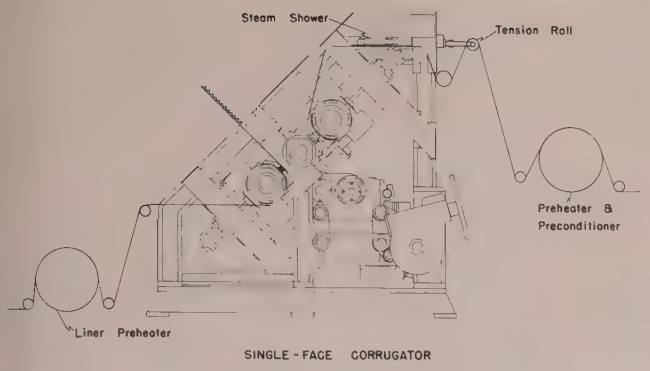

Fig. 1. Schematic diagram of single-facer unit

In general, these may be grouped into two broad classes: (1) material variables such as the tensile, stretch, caliper, shear, and frictional characteristics of the mediums, and (2) the operational variables associated with the operation. In the past there has been a great deal of speculation as to the relative importance of these two groups of variables. Because of the widespread speculation which has existed relative to the importance of these variables and the need for a better understanding of the fundamental principles involved in corrugating, a study on corrugating has been initiated at The Institute of Paper Chemistry. The purpose of this study is to develop basic information leading to a thorough knowledge of the fundamental principles involved in the corrugating operation and the relationship between the quality of the combined board and the operational and material variables. The current report is concerned with one phase—namely, the effect which nip pressure, web tension, corrugating speed, and steam pressure at the showers has on the quality of the combined board.

GENERAL PROCEDURE

In order to determine the effect of various operational variables on the physical characteristics of the combined board, four different types of corrugating medium were fabricated into A-flute, single-faced board using 42-lb. kraft linerboard as the facing and starch as the adhesive. The combined boards resulting from the various runs were evaluated for their physical properties.

Fabrication

All the fabrication runs were carried out on the Institute's experimental Langston corrugator (*1*). The experimental corrugator is schematically shown in Fig. 1 and consists of a single-face unit and auxiliary equipment such as elevating roll stands, tracking, preconditioner, etc. The unit is ruggedly built and is the same size as commercial units except for width. The regular Langston A-flute rolls, which are approximately 12 in. in diameter, were used in this study. The effective face of the rolls is 14 in. and the operating steam pressure is 150 p.s.i.

The adhesive assembly utilizes a reverse doctor roll. In addition to the usual provisions for adjusting roll clearances, the unit is equipped for controlling the relative speed between the transfer roll and the medium as well as the relative speed between the transfer and the doctor roll. The adhesive roll speed used in this study was 95% of the medium speed. The adhesive clearances were 0.016 in. for the transfer roll and 0.010 in. for the doctor roll. The same formulation of starch adhesive was used throughout the study. The viscosity from batch to batch was held at 28 to 31 seconds at 100°F. and the gelatinization point, 140 to 144°F.

The single-face unit is equipped with a liner preheater and a tracking medium preheater and preconditioner. After the preheater and immediately prior to the corrugating nip, the medium is further conditioned in what is essentially a steam chamber rather than by the use of the conventional steam showers. In order to control the initial web tension in the medium, a carrier roll supported by bearings mounted on two cantilever beams has been installed just prior to the steam chamber or showers. Each beam carries a strain gage and the web tension is measured in terms of the output of the gages. The degree of braking is varied by means of a TV antenna rotor motor whose control is mounted on the operating panel.

The operational variables and the conditions used are given in Table I. It should be emphasized that under each set of conditions the speed of the corrugator was progressively advanced until fracture of the flutes was obtained. The maximum speed shown in the tables of data is the maximum speed (within 25 f.p.m.) at which the particular medium would corrugate under the conditions used without fracture of the flutes.

Materials Used

The corrugating mediums used in this study consisted of four different types—i.e., straw, bogus, northern semichemical, and southern semichemical—of medium randomly selected. For each type of medium, five 12-in. width rolls were slit from a given parent roll. The diameter of the rolls varied from approximately 30 to 50 in. A new roll of medium of each type was used for the run series in each condition. The characteristics of the medium used are tabulated in Table II.

Table I. Conditions Used

Variables	*Corrugator speed.*[a] *f.p.m.*	*Web tension, lb./in. width*	*Nip pressure, lb./in. width*	*Steam shower, p.s.i.*	*Medium preconditioner temp., °F.*
A. Corrugator speed and nip pressure	150	0.5	220	14	350
	300	0.5	Repeat at	14	350
	450	0.5	340, 570,	14	350
	600	0.5	and 865	14	350
	750	0.5		14	350
	900	0.5		14	350
	1000	0.5		14	350
B. Corrugator speed and web tension	150	Repeat at	340	14	350
	300	0.5, 1.0,	340	14	350
	450	1.5, and	340	14	350
	600	2.0	340	14	350
	900		340	14	350
	1000		340	14	350
C. Corrugator speed and amount of steam at showers	150	0.5	340	Repeat for	350
	300	0.5	340	0, 7, 14,	350
	450	0.5	340	and 28	350
	600	0.5	340		350
	900	0.5	340		350
	1000	0.5	340		350

[a] In addition, for each condition medium run at maximum speed (within 25 f.p.m.) without fracture of the flutes.

Table II. Physical Characteristics of Corrugating Medium

Set no.	Run no.	Basis wt. lb./M ft.²	Caliper, points	Tensile, (in M.D.), lb./in.	Stretch, %	Coefficient of friction[a] Cold Felt	Cold Wire	250° F. Felt	250° F. Wire	Concora,[b] p.s.i.
A	Straw	30.2	10.4	49.3	1.9	0.330	0.346	0.282	0.268	47.2
	Northern semichem.	27.2	10.0	52.2	1.3	0.316	0.319	0.264	0.255	38.2
	Bogus	27.2	9.8	44.1	1.5	0.320	0.340	0.258	...	32.6
	Southern semichem.	26.6	9.8	48.0	2.1	0.331	0.326	0.278	0.270	44.1
B	Straw	31.8	10.8	54.1	1.9	0.346	0.338	0.280	0.284	48.2
	Northern semichem.	26.8	9.6	53.4	1.4	0.310	0.334	0.282	0.284	39.2
	Bogus	28.2	9.8	45.9	1.6	0.318	0.322	0.280	0.274	34.5
	Southern semichem.	25.4	10.3	46.3	2.0	0.326	0.324	0.282	0.280	39.5
C	Straw	29.2	9.8	46.0	1.8	0.318	0.326	0.256	0.256	35.4
	Northern semichem.	27.1	9.9	56.4	1.3	0.298	0.312	0.238	0.242	38.3
	Bogus	27.4	10.1	42.5	1.5	0.320	0.318	0.260	0.258	31.9
	Southern semichem.	25.2	10.0	45.4	2.0	0.319	0.322	0.281	0.260	39.4

[a] Kinetic coefficient.
[b] Tested after conditioning for 15 to 45 min. at 50% R.H.

Evaluation

As mentioned previously, the maximum speed at which a given medium would fabricate without fracture of the flutes was determined for each condition. The presence of fractures was determined by delaminating the "green" board as it emerges from the pressure nip and visually examining the medium for fractures by viewing the medium against a strong light. This procedure was employed because it has been observed that incipient fractures are more readily detected by this procedure than by viewing the combined board.

The single-faced board was evaluated for flat crush, pin adhesion, and caliper after conditioning in accordance with standard practice. The procedures used are as follows.

Caliper

The caliper of the single-faced board was obtained by measuring the height of six consecutive flutes on each of ten specimens per sample. A special caliper was used consisting of a dead weight loaded Federal gage having 0.0005-in. graduations and a flat rectangular foot 0.5 by 0.6 in. All measurements were made using a 125-g. load on the foot. The caliper measurements were computed in two ways—i.e., average caliper and average difference between consecutive flutes. The former was computed as the average of the 60 individual determinations. The average difference in the height of consecutive flutes is reported as the average of 50 determinations. The average difference in consecutive flutes is used as a measure of the tendency for a given medium to exhibit high-low corrugations and thus, is directly associated with runability.

Flat Crush

Ten, 5-sq. in. circular specimens were tested for each sample on an H. and D. compression tester. The reported values for flat crush is the average of the ten individual determinations.

Table III. Effect of Corrugating Speed on Physical Characteristics of Combined Board

Set no.	Run no.	Corrugator conditions: Corrugating speed, f.p.m.	Web tension, lb./in.	Nip pressure, lb./in.	Combined board characteristics: Flat crush, p.s.i.	Pin adhesion,[a] lb./6 in.²	Caliper: Average, points	Caliper: Difference in consecutive flutes, points
				Straw				
A	1	150	0.5	340	43.1	76(4-1-0)	194.9	1.1
	2	300	0.5	340	41.2	100(3-2-0)	195.2	1.5
	3	450	0.5	340	42.0	89(4-1-0)	195.7	2.2
	4	600	0.5	340	41.4	93(5-0-0)	195.4	2.0
	5	775	0.5	340	41.5	93(0-5-0)	194.3	3.6
				Northern Semichemical				
A	6	150	0.5	340	31.7	91(3-2-0)	196.5	0.9
	7	300	0.5	340	32.0	85(5-0-0)	196.5	1.5
	8	450	0.5	340	33.2	91(5-0-0)	196.7	1.5
	9	600	0.5	340	34.7	80(3-2-0)	196.3	1.8
	10	750	0.5	340	33.8	51(0-5-0)	195.4	3.1
				Southern Semichemical				
A	11	150	0.5	340	40.2	94(5-0-0)	194.8	2.2
	12	300	0.5	340	39.9	95(3.5-1.5-0)	195.4	2.1
	13	450	0.5	340	40.3	98(2.5-2.5-0)	195.4	2.3
	14	600	0.5	340	40.3	91(0-5-0)	195.0	2.3
	15	750	0.5	340	39.8	82(1-4-0)	194.9	1.6
	16	900	0.5	340	39.2	45(0-2-3)	194.1	2.9
	17	1000[b]	0.5	340	37.8	29(0-0-5)	194.0	3.9
				Bogus				
A	18	150	0.5	340	30.1	56(0-3-2)	195.0	1.0
	19	300	0.5	340	30.6	75(2-3-0)	195.6	1.1
	20	450	0.5	340	29.8	71(5-0-0)	196.0	1.6
	21	600	0.5	340	30.9	77(4-1-0)	195.8	2.3
	22	750	0.5	340	30.3	63(0-5-0)	194.9	1.9
	23	900	0.5	340	31.2	41(0-0-5)	195.1	3.3
	24	1000[b]	0.5	340	30.3	26(0-0-5)	195.4	3.7

[a] Values in parentheses from left to right represent failure due to fiber-fiber, fiber-adhesive, and adhesive-adhesive, respectively.
[b] Maximum speed used in this study.

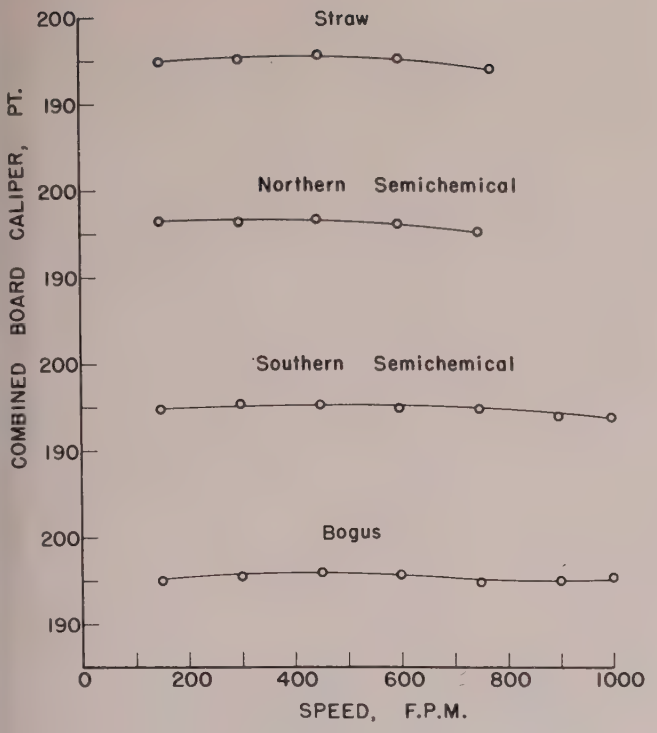

Fig. 2. Average caliper versus *speed*

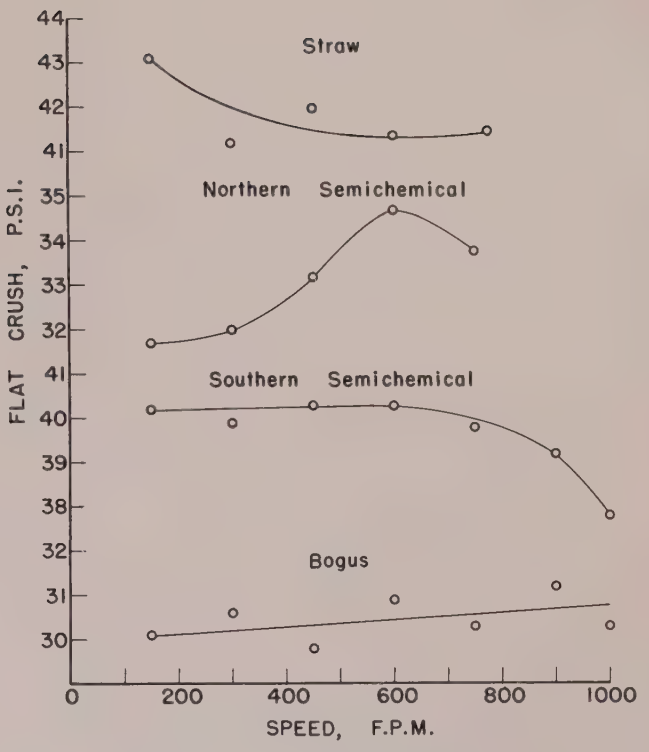

Fig. 4. Flat crush versus *speed*

Pin Adhesion

From each of five specimens of single-faced board, one specimen, 2 by 3 in., was cut with the 2-in. direction parallel to the flutes. Long and short pins were alternately inserted in the flutes. The thus-prepared specimen was mounted in a pin adhesion rack assembly and force applied until the medium separated from the single-face liner. The average force is reported as the pin adhesion.

DISCUSSION OF RESULTS

As previously mentioned, four different types of medium were fabricated under varying conditions for the purpose of determining the effect of speed, nip pressure, web tension, preconditioner temperature, and amount of steam at the showers on runability and combined board characteristics.

Effect of Speed

The results obtained on the four different mediums corrugated under the same operational conditions except for

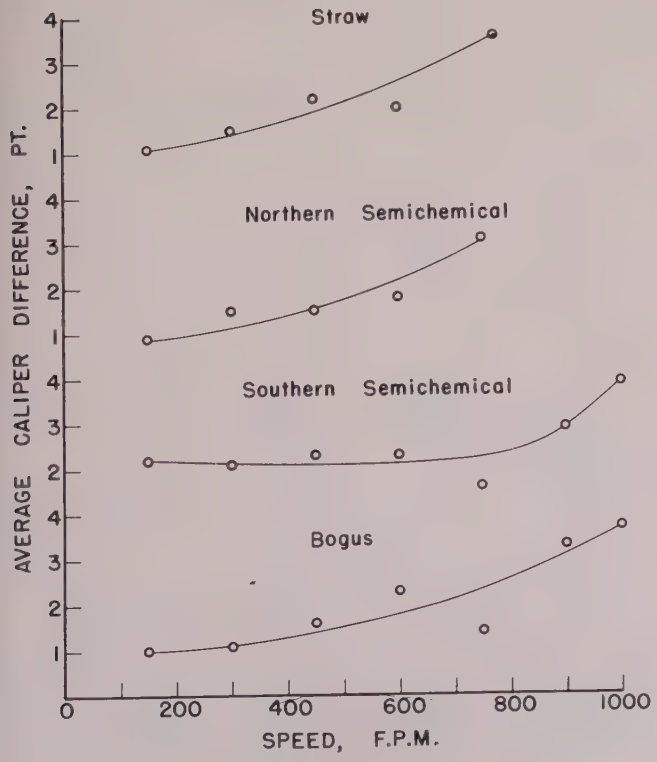

Fig. 3. Average caliper difference versus *speed*

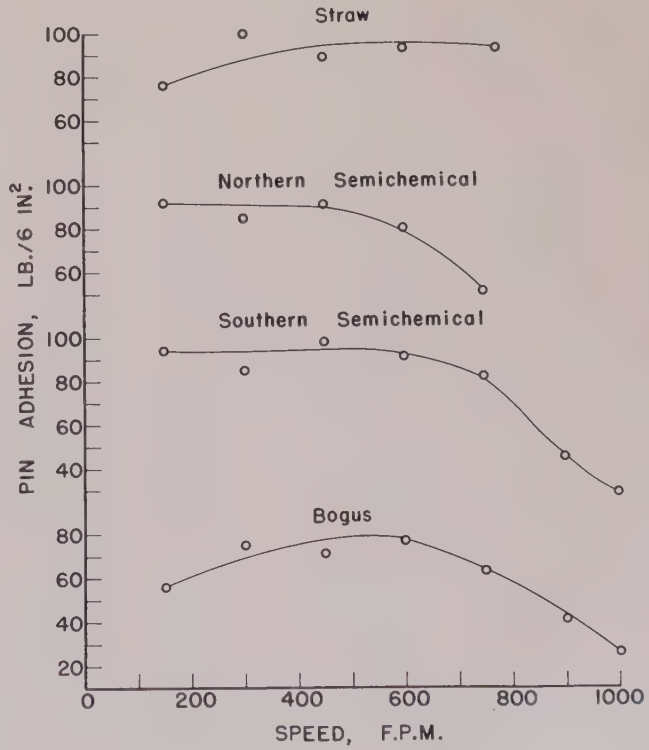

Fig. 5. Pin adhesion versus *speed*

Table IV. Effect of Nip Pressure on Runability

Set no.	Run no.	Nip pressure, lb./in. nip	Web tension, lb./in. width	Maximum fabricating speed, f.p.m.	Caliper difference in consecutive flutes, points
			Straw		
B	1	220	0.5	825	3.2
	2	570	0.5	800	2.5
	3	865	0.5	825	2.4
			26-lb. Northern Semichemical		
B	4	220	0.5	825	4.4
	5	340	0.5	750	3.1
	6	570	0.5	750	...
	7	865	0.5	750	1.7
			26-lb. Southern Semichemical		
B	8	220	0.5	1000	2.9
	9	340	0.5	1000	3.9
	10	570	0.5	825	2.8
	11	865	0.5	850	2.0
			Bogus		
B	12	220	0.5	1000	5.6
	13	340	0.5	1000	3.7
	14	570	0.5	750	2.8
	15	865	0.5	750	2.8

corrugator speed are tabulated in Table III. The maximum speed shown for each medium in Table III represents the maximum speed, within 25 f.p.m., at which that particular medium would corrugate without fracture of the flutes. It may be noted that the four mediums exhibited quite different critical speeds insofar as runability is concerned. Based on this and previous studies, it appears that rolls of corrugating medium, even within a given type, may vary considerably insofar as the critical speed is concerned—i.e., the speed at which fracture of the flutes occurs.

Table V. Effect of Nip Pressure at Constant Speed (at Constant Speed Levels)

Set no.	Run no.	Nip pressure, lb./in. width	Web tension, lb./in. width	Corrugating speed, f.p.m.	Flat crush, p.s.i.	Pin adhesion, lb./6 in.^{2}	Caliper	
							Average, points	Difference in consecutive flutes, points
				Straw				
B	16	220	0.5	300	40.9	107	195.6	2.4
	17	340	0.5	300	41.2	100	195.2	1.5
	18	570	0.5	300	39.1	95	195.7	1.7
	19	865	0.5	300	34.8	90	196.1	1.5
	20	220	0.5	600	40.5	99	194.6	2.6
	21	340	0.5	600	41.4	93	195.4	2.0
	22	570	0.5	600	38.5	92	196.3	1.9
	23	865	0.5	600	35.0	87	195.7	2.3
				Northern Semichemical				
B	24	220	0.5	300	32.6	91	196.5	1.3
	25	340	0.5	300	32.1	85	196.5	1.5
	26	570	0.5	300	33.1	85	196.3	1.8
	27	865	0.5	300	34.1	80	196.1	1.4
	28	220	0.5	600	33.5	81	194.9	2.2
	29	340	0.5	600	34.7	80	196.3	1.8
	30	570	0.5	600	33.1	75	196.4	1.6
	31	865	0.5	600	34.4	78	196.6	1.8
				Southern Semichemical				
B	32	220	0.5	300	41.2	98	194.9	1.6
	33	340	0.5	300	39.9	95	195.4	2.1
	34	570	0.5	300	41.2	99	194.8	1.3
	35	865	0.5	300	40.4	93	194.5	1.9
	36	220	0.5	600	41.0	80	193.6	3.9
	37	340	0.5	600	40.3	91	195.0	2.3
	38	570	0.5	600	39.9	99	194.9	2.6
	39	865	0.5	600	39.9	99	194.8	2.0
				Bogus				
B	40	220	0.5	300	30.2	66	195.5	2.6
	41	340	0.5	300	30.6	75	195.6	1.1
	42	570	0.5	300	30.4	73	195.2	2.1
	43	865	0.5	300	30.7	75	194.6	2.0
	44	220	0.5	600	30.6	73	194.5	2.3
	45	340	0.5	600	30.9	77	195.8	2.3
	46	570	0.5	600	29.5	67	195.2	1.9
	47	865	0.5	600	30.3	49	195.2	2.0

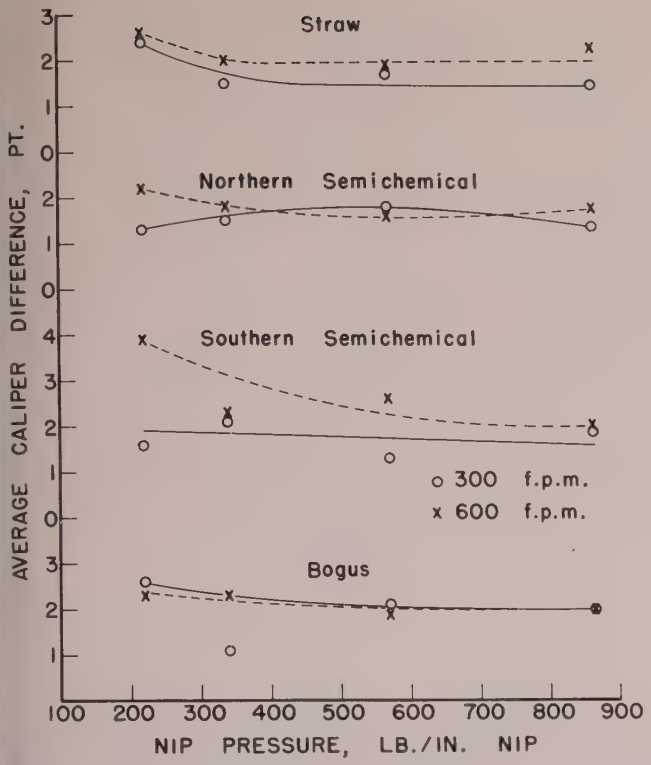

Fig. 6. Relationship between nip pressures and high-low corrugations (at critical speed levels)

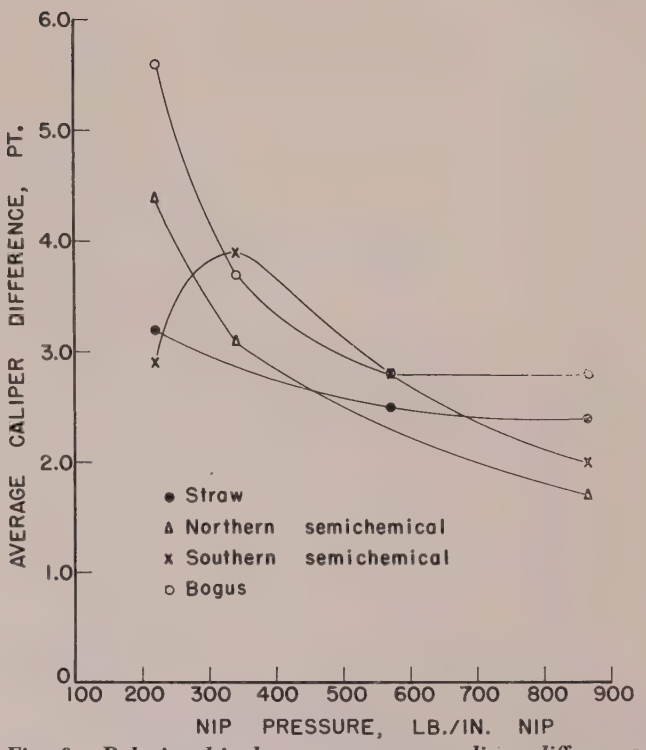

Fig. 8. Relationship between average caliper difference between consecutive flutes

When the caliper results given in Table III and illustrated in Fig. 2 are considered, it may be seen that increasing the speed had no really significant effect on lowering the caliper except possibly as the critical speed was approached such as in the case of the northern semichemical medium. However, when the average difference in the caliper of consecutive flutes is considered (see Fig. 3), it may be noted that, in general, the average difference in caliper increased as the speed increased. The difference in consecutive flute height was determined because it is believed to be a good way of measuring the susceptibility of a given medium to produce high-low corrugations. The higher the average caliper difference, the greater is the difference in the caliper of consecutive flutes and, thus, the tendency toward high-low corrugations. This phenomenon is a measure of runability in addition to the critical speed mentioned before. In some converter's plants poor runability manifests itself in the form of high-low corrugations whereas in others fracture of the flutes is a greater issue. It may be noted in Fig. 4 that the incident of high-low corrugations varies for the different mediums used in this study.

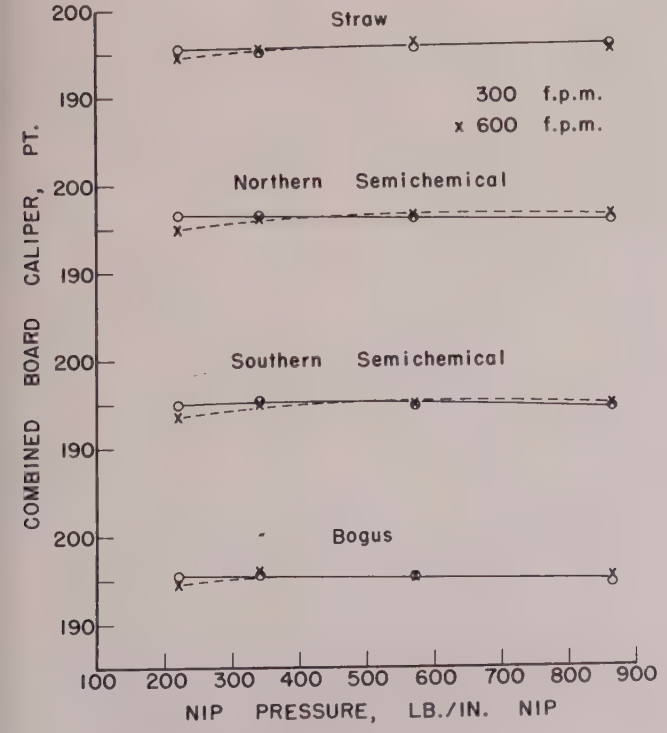

Fig. 7. Relationship between nip pressure and caliper

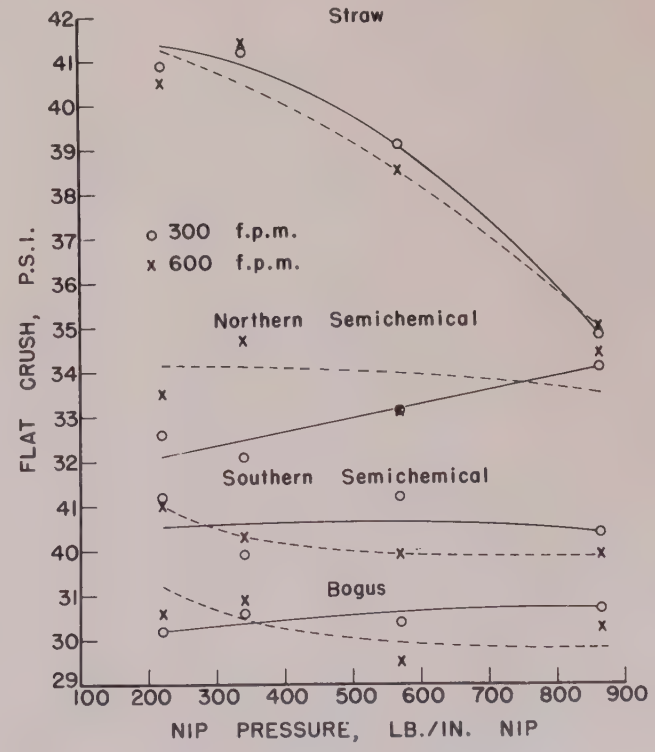

Fig. 9. Relationship between nip pressure and flat crush

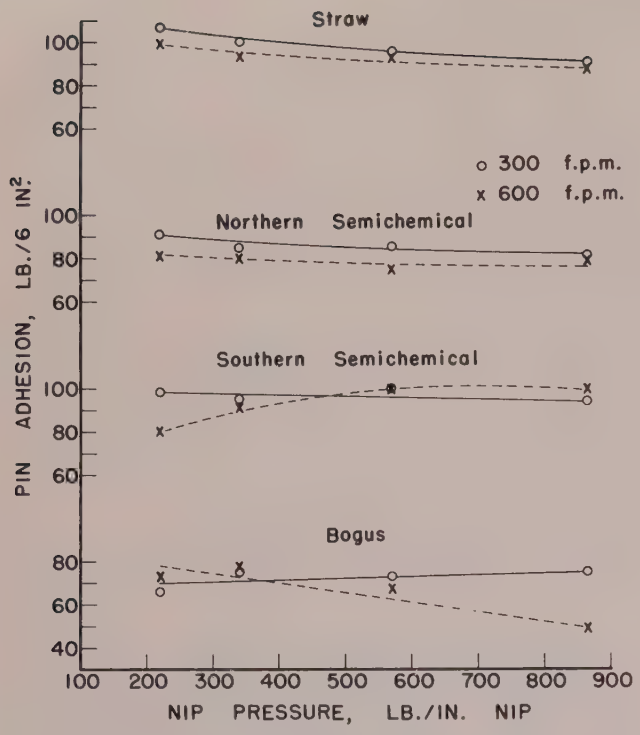

Fig. 10. Relationship between nip pressure and pin adhesion

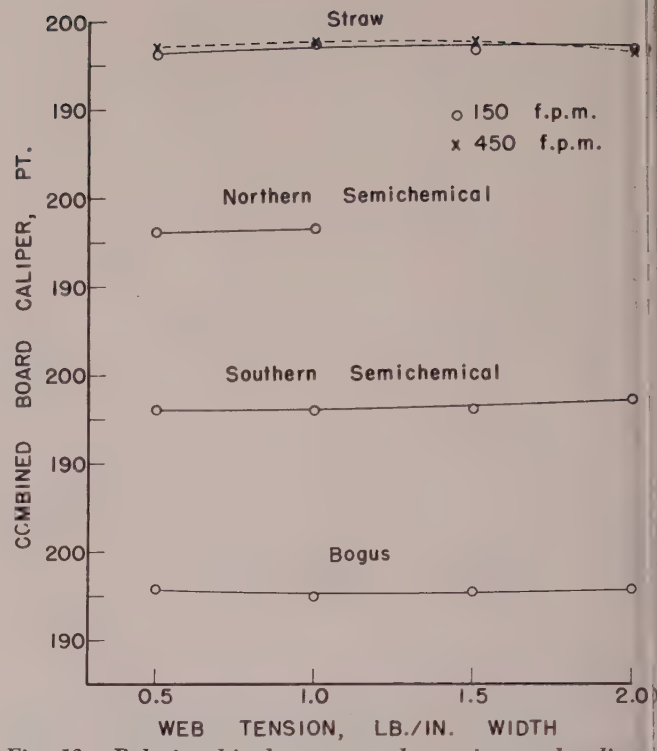

Fig. 12. Relationship between web tension and caliper

Experience has indicated that the rates of change indicated by the different mediums are not necessarily a characteristic of that given type of medium, rather it is a characteristic of that particular roll of medium. In addition, the average difference in the caliper of consecutive flutes increases rapidly as the critical speed is approached, although the critical speeds were of a different magnitude for each medium.

The effect which corrugator speed has on flat crush is illustrated in Fig. 4. With the exception of the northern semichemical medium, there was no marked change in flat crush up to about 600 f.p.m. Beyond this speed, the southern semichemical medium exhibited a reduction in flat crush. The behavior of the northern semichemical was not consistent with the other mediums. It has been observed in other similar studies that frequently the flat crush will decrease slightly at near the critical speed.

The effect of corrugator speed on adhesion is illustrated in Fig. 5. In general, there was no marked change up to approximately 600 f.p.m. although the level of adhesion was less for the bogus medium. Above 600 f.p.m., the adhesion

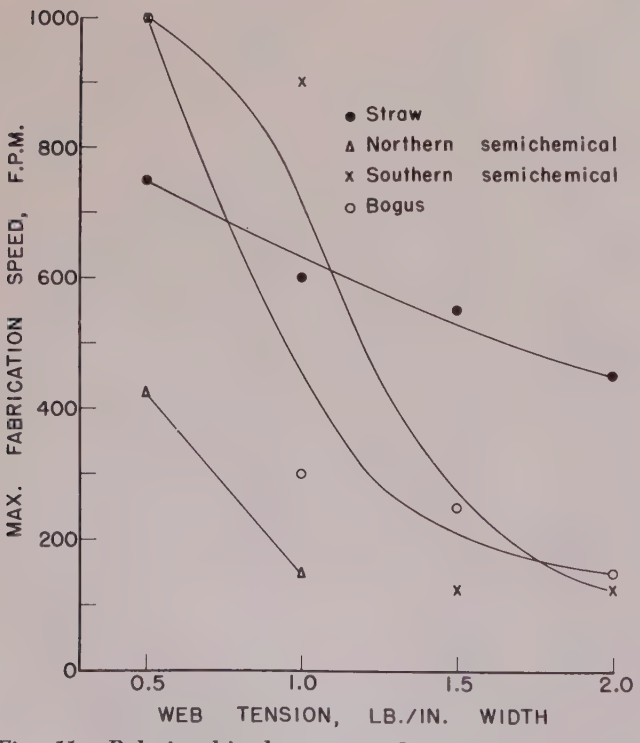

Fig. 11. Relationship between web tension and runability

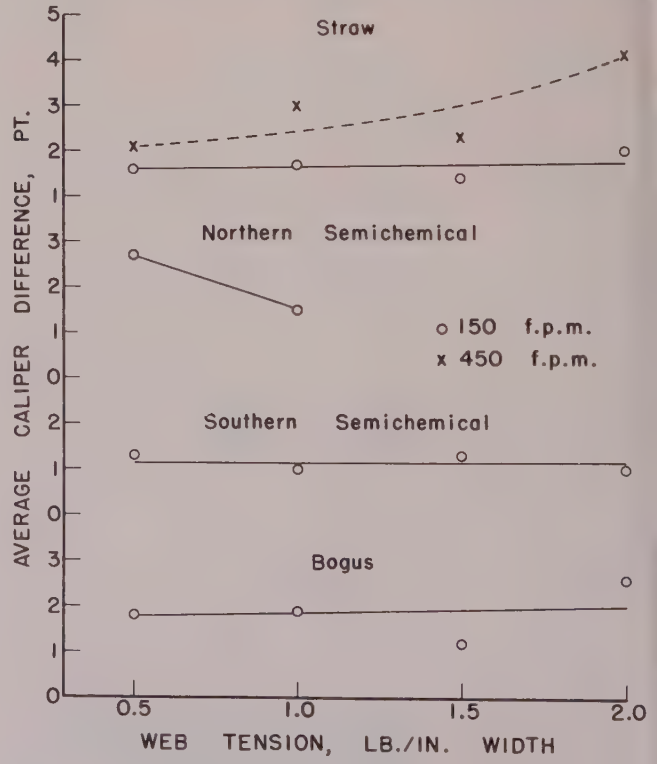

Fig. 13. Relationship between web tension and high-low corrugations

Table VI. Effect of Web Tension

Set no.	Run no.	Web tension, lb. in. width	Nip pressure, lb./in. nip	Maximum fabrication speed, f.p.m.
		Straw		
C	1	0.5	340	750
	2	1.0	340	600
	3	1.5	340	550
	4	2.0	340	450
		Northern Semichemical		
C	5	0.5	340	425
	6	1.0	340	150
		...	...	Fractured at minimum speed
		Southern Semichemical		
C	7	0.5	340	1000
	8	1.0	340	900
	9	1.5	340	125
	10	2.0	340	125
		Bogus		
C	11	0.5	340	1000
	12	1.0	340	300
	13	1.5	340	250
	14	2.0	340	150

decreased as the speed increased. This behavior would be expected in that, at the higher speeds, there is not sufficient heat transfer to cause the starch to gelatinize fully. This effect may be seen, as noted from the results given in parentheses for the pin adhesion data. The first value represents the number of specimens which failed due to fiber-fiber bond failure, the second, fiber-adhesive and the third, cohesion of the adhesive.

Effect of Nip Pressure

Max (*3*), working with a laboratory corrugator with 8-in. diameter A-flute rolls at a speed of 100 to 130 f.p.m., reports that over a nip pressure range of approximately 10 to 160 lb. that the maximum flat crush occurred at relatively low nip pressure, i.e., approximately 15 to 62 lb. per in. width. Caliper increased rapidly at lower nip pressure and then tended to level off above 40 to 60 lb. per in. In general,

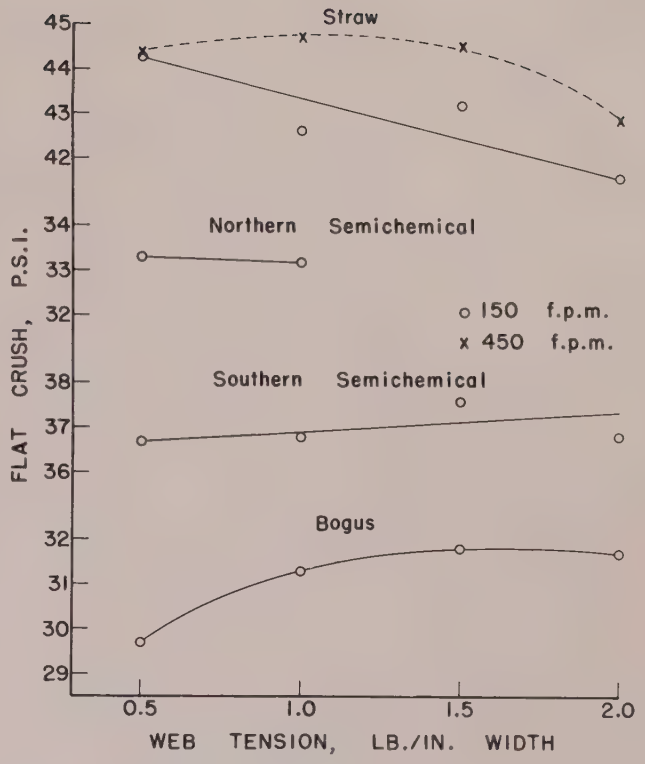

Fig. 14. Relationship between web tension and flat crush

compression appeared to increase slightly with increase in nip pressure.

The effect of varying the nip pressure on runability and combined board characteristics in this study was carried out at a range of nip pressure of approximately 220 to 865 lb. per in. nip width. In order to study the effect on runability as measured in terms of critical speed and incidence of high-low corrugations, the critical speed for each medium was determined at various levels of nip pressure. The results are tabulated in Table IV. It may be noted that, with the exception of the straw medium, increasing the nip pressure resulted in a lowering of the critical speed level. The "break-

Table VII. Effect of Web Tension on Combined Board Characteristics

Set no.	Run no.	Web tension, lb./in. width	Nip pressure, lb./in. nip	Fabricating speed, f.p.m.	Flat crush, p.s.i.	Pin adhesion, lb./6 in.[1]	Caliper: Average, points	Caliper: Average difference in consecutive flutes, points
				Straw				
C	15	0.5	340	150	44.3	75	196.2	1.6
	16	1.0	340	150	42.7	73	197.1	1.7
	17	1.5	340	150	43.3	82	196.2	1.4
	18	2.0	340	150	41.7	90	196.3	2.0
	19	0.5	340	450	44.4	90	196.8	2.1
	20	1.0	340	450	44.8	90	197.2	3.5
	21	1.5	340	450	44.6	97	197.0	2.3
	4	2.0	340	450	43.0	90	196.0	4.1
				Northern Semichemical				
C	22	0.5	340	150	33.3	86	196.1	2.7
	23	1.0	340	150	33.2	69	196.3	1.5
				Southern Semichemical				
C	24	0.5	340	150	36.7	100	196.0	1.3
	25	1.0	340	150	36.8	91	195.9	1.0
	9	1.5	340	125	37.6	96	195.9	1.3
	10	2.0	340	125	36.8	100	197.0	1.0
				Bogus				
C	26	0.5	340	150	29.7	79	195.8	1.8
	27	1.0	340	150	31.3	78	194.9	1.9
	28	1.5	340	150	31.8	74	195.4	1.2
	14	2.0	340	150	31.7	76	195.7	2.6

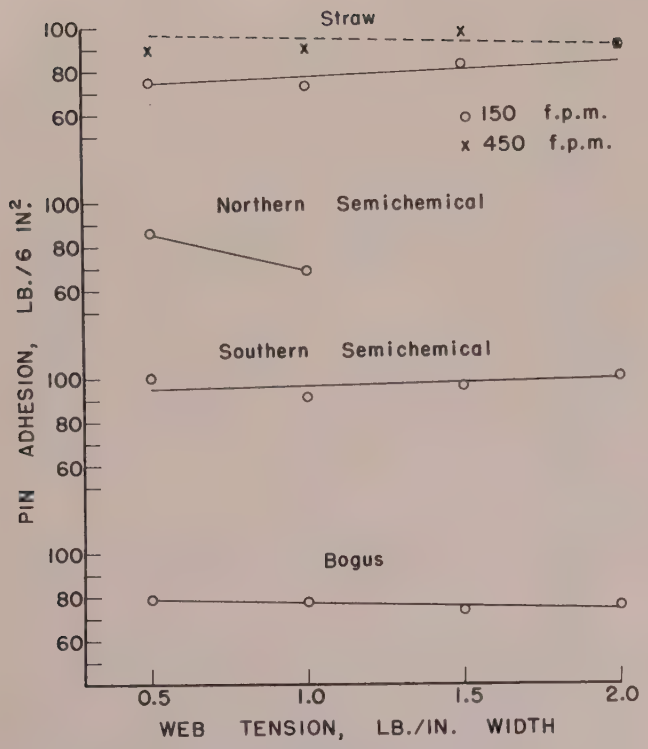

Fig. 15. Relationship between web tension and pin adhesion

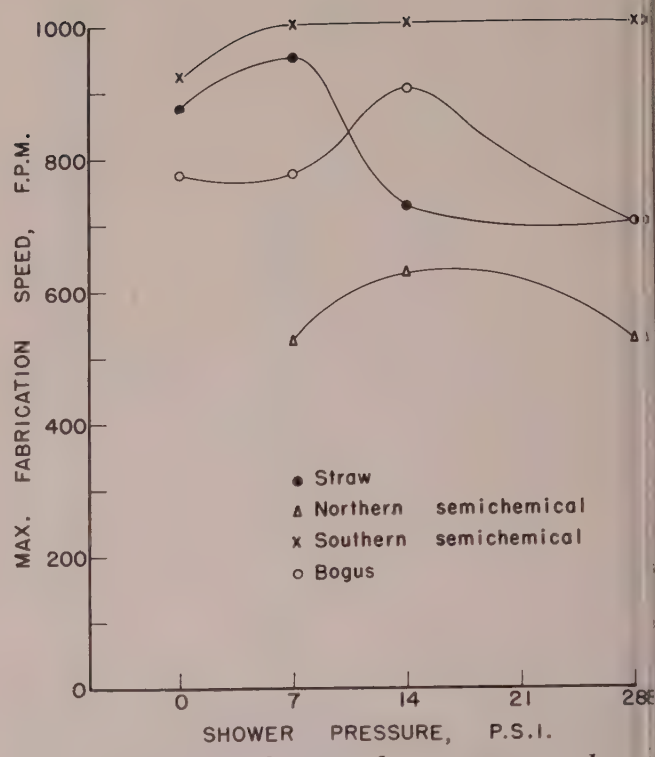

Fig. 16. Relationship between shower pressure and runability

point" appears to be between 340 and 570 lb. per in. of nip, although this may vary with the medium. Had a higher web tension been used, it is anticipated that the effect on runability in terms of critical speed might have been greater. Apparently, at the higher nip pressures, the medium is stressed (locally) more. When the effect of nip pressure on runability in terms of incidence of high-low corrugations are concerned, it may be seen that the higher the nip pressure, the lower the average difference in caliper of consecutive flutes (see Fig. 6). However, the critical speed is also reduced; thus, it is not clear cut from these data which is the dominant cause of the reduction in tendency toward high-low corrugations.

The effect of varying nip pressures on the characteristics of the combined board was determined by fabricating the four different mediums at various levels of nip pressure at each of two corrugating speeds. The results are tabulated in Table V and illustrated in Fig. 7. It may be noted from Fig. 7 that increasing the nip pressure from 220 to 865 lb. per in. of nip width had no significant effect on the average caliper at the two speed levels used; however, as was pointed out earlier, at near the critical speed, the incidents of high-lows increased.

Table VIII. Effect of Amount of Steam at Showers on Runability

Main shower pressure, p.s.i.	*Nip pressure, lb./in. nip*	*Maximum fabrication speed, f.p.m.*	*Average caliper difference between consecutive flutes, points*
		Straw	
0	340	875	3.5
7	340	950	2.6
14	340	725	2.8
28	340	700	2.5
		Northern Semichemical	
0	340	[a]	...
7	340	525	2.7
14	340	625	2.7
28	340	525	2.7
		Southern Semichemical	
0	340	925	4.4
7	340	1000	2.7
14	340	1000	2.9
28	340	1000	2.3
		Bogus	
0	340	775	4.2
7	340	775	4.1
14	340	900	3.1
28	340	700	4.0

[a] Fractured at 25 f.p.m. with no steam.

The results of the average caliper difference between consecutive flutes tabulated in Table V are graphically illustrated in Fig. 8. It may be noted that there is a slight tendency for the average caliper difference between consecutive flutes to decrease as the nip pressure is increased; however, it is questionable if the change is of real significance.

The flat-crush results tabulated in Table V have been plotted in Fig. 9 to illustrate the effect of nip pressure on flat-crush characteristics. In the case of the straw medium, increasing the nip pressure was accompanied by a decrease in flat crush both at 300 and 600 f.p.m., the maximum reduction being of the order of 10 to 12%. The bogus, northern and southern semichemical mediums on the other hand did not exhibit any marked change in flat crush with change in nip pressure. It might be theorized that the higher the nip pressure, the better would be the molding and, consequently, a higher caliper might result which would be conducive to lower flat crush. It is believed, however, that the nip pressures used were of such a magnitude that there may have been little change in the degree of molding.

The pin-adhesion results are graphically presented in Fig. 10. It may be seen that increasing the nip pressure tended to cause a slight reduction in pin adhesion; however, it is questionable if the reduction in adhesion as a result of increased nip pressure is significant.

Web Tension

In a survey made some years ago (*2*) adjustment of web tension was suggested as one of the principal ways of minimizing the occurrence of high-low corrugations. It may be shown by reference to the action taking place in the labyrinth that a small increase in web tension is reflected in a sub-

Table IX. Effect of Amount of Steam at Showers

Run no.	Amount of steam at showers, p.s.i.	Web tension, lb./in. width	Nip pressure, lb./in. nip	Corrugating speed, f.p.m.	Flat crush, p.s.i.	Pin adhesion, lb./6 in.²	Caliper	
							Average, points	Average difference in consecutive flutes, points
				Straw				
1	0	1/2	250	450	33.0	93	195.2	3.3
	7	1/2	250	450	33.1	103	195.6	1.8
	14	1/2	250	450	43.9	97	194.1	1.6
	28	1/2	250	450	45.0	96	195.3	1.7
				Northern Semichemical				
2	0	[a]	[a]	[a]	[a]	[a]	[a]	[a]
	7	1/2	250	450	36.2	88	196.2	2.2
	14	1/2	250	450	34.8	94	195.1	1.8
	28	1/2	250	450	36.0	96	195.1	2.9
				Southern Semichemical				
3	0	1/2	250	450	34.1	84	198.4	2.6
	7	1/2	250	450	37.5	93	196.2	1.8
	14	1/2	250	450	41.4	91	196.0	1.7
	28	1/2	250	450	36.8	94	195.7	1.6
				Bogus				
4	0	1/2	250	450	27.6	77	197.6	2.3
	7	1/2	250	450	31.2	77	195.7	3.0
	14	1/2	250	450	31.1	75	196.5	1.8
	28	1/2	250	450	32.3	84	194.6	2.7

[a] Fractured at 150 f.p.m.

stantial increase in the stresses imposed on the medium during its passage betweeen the fluted rolls. In order to determine the order of magnitude of this effect on runability of the medium as well as certain characteristics of the combined board, each of the four mediums used in this study were fabricated using different levels of web tension.

The effect on runability was carried out by determining the maximum speed of the corrugating at which each medium could be run under different degrees of web tension without fracturing the flutes. The results of this phase of the study are given in Table VI. It may be observed from the graphic illustrations in Fig. 11 that increasing the web tension has a very pronounced effect on runability as measured in terms of the occurrence of fractured flutes. The roll of northern semichemical was more sensitive to web tension and straw the least sensitive.

The relationship between web tension and combined board characteristics may be observed from the data tabulated in Table VII and illustrated in Figs. 12 through 15. The data in Table VII were obtained by fabricating each roll of medium at constant operating conditions except for web tension and speed. It may be seen in Fig. 12 that increasing the web tension did not materially change the average caliper of the single-faced board. As may be seen in Fig. 13, increasing the web tension generally did not introduce any marked change in the incident of high-low corrugations.

When flat crush is considered (see Fig. 14), it may be noted that, in general, increasing the web tension did not introduce a significant change in flat crush. Ths same relationship may be noted in Fig. 15 for pin adhesion.

The Effect of the Amount of Steam at the Showers

There has always been a great deal of speculation as to the role of the steam showers in corrugating board. One view seems to be that the moisture obtained via the showers is necessary for plasticizing the sheet such that it will mold better. Another view is that the heat is the dominant factor in helping to plasticize the medium and the main purpose of the shower is as an aid in the better transfer of heat. In order to help resolve the role of the steam showers, an abridged study was carried out in which fabrication runs were made with each of the four mediums in which the amount of the steam at the showers was varied from 0 to 28 p.s.i. The steam at the preconditioner shower was proportionally varied with that at the main shower; however, this was done manually by adjusting the valve on the steam inlet to the preconditioner shower. The usual operating conditions employ approximately 1 p.s.i. steam at the preconditioner shower when the main showers are at 14 p.s.i.

The effect which the amount of steam at the showers has on runability may be seen from the data tabulated in Table VIII and graphically presented in Fig. 16. It seems worthy of mention that the straw, southern semichemical and the bogus medium exhibited fairly good runability in terms of maxi-

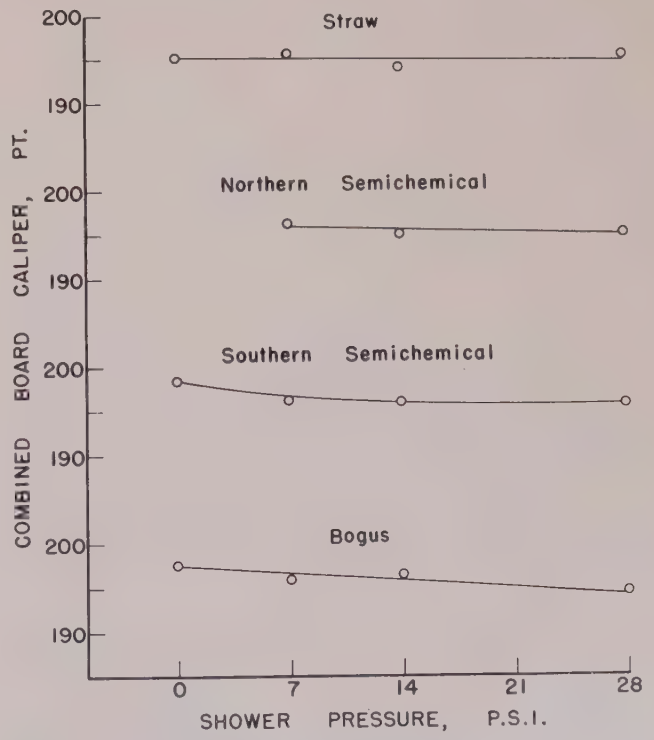

Fig. 17. Relationship between shower pressure and caliper

mum fabrication speed without fracture when no showers were used. On the basis of the behavior of these four mediums, there appears to be an optimum shower pressure in terms of runability for each medium. For all but the straw medium, 14 p.s.i. appears to give equal or better runability. The maximum runability with the straw was at 7 p.s.i. shower pressure. The above behavior does not appear to be directly related to initial moisture content as may be seen by reference to the following moisture contents:

Medium	*Moisture, %*
Straw	6.9
Northern semichemical	7.6
Southern semichemical	8.4
Bogus	7.8

The effect which the shower pressure had on the physical properties of the combined board may be seen from the results tabulated in Table IX and graphically presented in Fig. 17. It may be noted in Fig. 17 that there is a slight tendency for the caliper to decrease with increase in shower pressure; however, it is questionable in most cases if the change is significant.

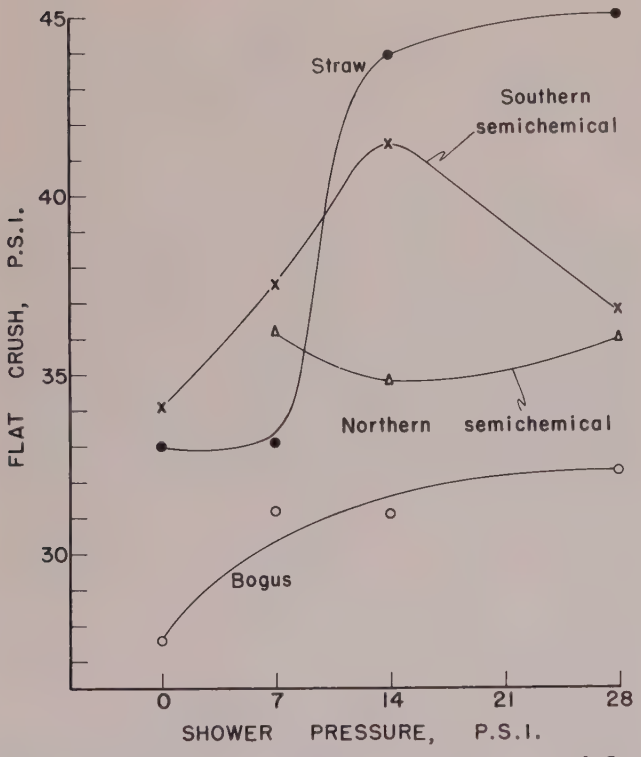

Fig. 18. Relationship between shower pressure and flat crush

The relationship between flat crush and shower pressure presented in Fig. 18 indicates that, with the exception of the northern semichemical, a shower pressure of approximately 14 p.s.i. gives about the maximum flat crush. The pin adhesion and incident of high-low corrugations do not appear to be markedly influenced by a variation in the shower pressure.

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Less Warp, Less Gluing, More Speed

D. B. PHILLIPS

Longview Fibre Co. has attacked the problem of warp and double-back adhesion from two angles. Curiously enough each approach was made independently of the other and at the same time. Also, as a contrast, the belt drying system as developed at Longview evolved first from a theory, but the glue roll thread-up at Oakland came about from an accidental thread-up on a corrugator. It is quite unusual to have two projects complement each other as nicely as these two did and, in fact, one proved part of the theory of the other.

In Longview, the long standing concept that wet edges were due to the flow of moisture outwards along the flutes was given careful scrutiny. After considerable thought and discussion, it was felt that this concept was not correct because of several physical conditions. The ability to evaporate moisture depends on air pressure and certainly the pressure in the middle of the sheets would be somewhat greater than on the edges where the open ends of the flutes would relieve it. Also, the dwell time on the hot plates is of short duration and time for generation of moisture vapor and flow to the edges of the sheet was not sufficient to be responsible for all the moisture present on the edges. Furthermore the edges would not condense vapor coming from the center. Edges have always been somewhat better on narrow width sheets because of the greater available heat from the cast iron steam chests than on the wider sheets. We think it is quite a common accepted fact that normally corrugators have more trouble on their widest width paper on the edges than on the narrow widths.

Therefore, our Longview people evolved the theory that the edges were wet because the top corrugator belts became saturated along that area and were no longer able to perform their normal blotter function. This wet streak probably migrated back toward the center of the web and outwards somewhat, thus giving a streak some 2 to 3 in. wide. If this theory were true, then one should be able to find the wet streak on the belts by holding his hand a fraction of an inch or so away and feeling the steam cause his hand to sweat. This was found to be true and we were able to determine without looking at the sheet where the edge of it was by finding the wet streak on the belts. The wet streak was then followed all the way back to the tail pulley where re-entry to the hot plates occurred.

Feeling then that the theory, that wet edges were caused by a wet streak in the belt, had been substantiated, we proceeded to consider means of correction. We knew that paper machine felts had been dried for some years by forced hot air and that perhaps a similar system would be the correct approach. The system we finally installed consisted of a blower, steam coil, and hot air ducts (Fig. 1).

The construction of the drier system consists of blowers with capacities of from 5500 to 7000 cu-ft. per min., depending on the size of corrugator. The blower forces room-temperature air through a McQuay, type S-82, 36 in. tube face by 42 in. NTL steam heating coil, then through the hot-air ducts as illustrated in the picture. The velocity of air is from 5500 to 6000 f.p.m. in a temperature range of 135 to 155°F. The ratio of air is approximately $3^1/_2$ to 1 between top and bottom belts. The steam pressure used in the coils varies from 50 to 160 lb.

Making the hot air nozzles adjustable and so that they could be turned off and on was considered; however, knowing the tendency of corrugator crews for turning the right one *on* and the wrong one *off*, we decided to space the nozzles clear across the belt and to have them operate all the time. The system would be either completely on or completely off. In five of

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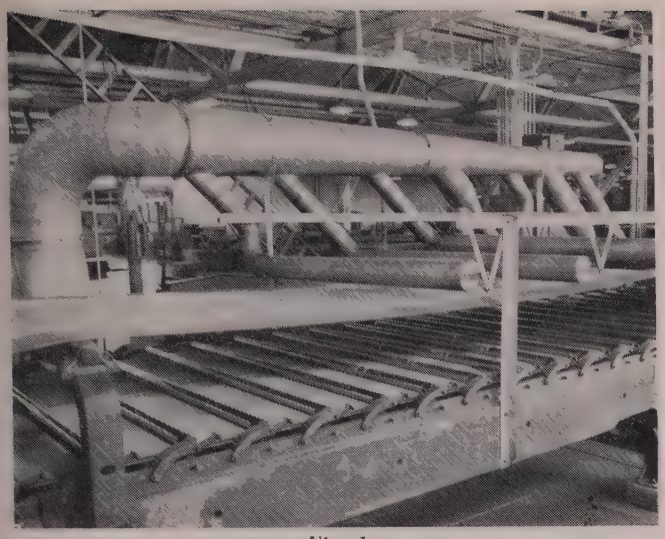

Fig. 1

our installations, the air stream blows against the travel of the belt, thus having a good scouring action. In two of our corrugators, the air jets blow with the travel because of ventilation problems affecting crew comfort.

We might mention in passing that we also considered the feasibility of making one hot plate a vacuum suction box to remove additional moisture from the bottom of the sheet. A pilot installation was made at Longview and the effectiveness of the water removal was promptly demonstrated by the creation of an indoor rainstorm at the exhaust of the vacuum pump. We have not pursued this phase of the system because the vacuum box tended to fill up with paper fuzz and other debris, plus the fact that it caused some troubles on splices. In addition, we felt we were getting our board dry enough by the use of the top belt drier with some moderate drying of the bottom belt.

We have found that the belt drier is a tool that has increased speeds by as much as 50 f.p.m. and has contributed substantially to the reduction of warp. There are certain grades that it is not used on such as very light partition stock liners and some bleached liner grades.

The second part of our double-back improvement program came out of our Oakland plant and is a system that they developed by trial and error. It all started one night by a chance thread-up on the glue machine by going over the small crowned spreader roll just ahead of the rider roll instead of under. The foreman on duty, being of inquisitive nature, decided to let it run for a while just to see what happened. After an hour or so of operation in which he sampled the production many times front, center, and back, he reported that the average was better than with the conventional thread-up. This started the ball rolling and we must say that for a year and a half we threw out the new thread-up many times and then reinstated it because, on the average, we were not able to get as good a pattern without it as we could with it. During this period we proceeded on the basis that if the total glue machine thread-up and glue application mechanisms were better built and better engineered, then the results would become much better.

In general, we found that we had to heavy-up the rider roll and the spreader roll, as well as put on heavier cross shafts and heavier bearings on the glue rolls. We found that the glue rolls and bearings were not in good enough shape to run the thin films we needed. We also found that offsetting the rider roll $^1/_2$ to $^3/_4$ in. back of center greatly reduced the criticalness of its setting. This has proved to be very helpful. All these points were corrected one by one in this year and a half of cut and try until the Oakland glue roll thread-up exists today as illustrated by Fig. 2. Construction, operation, and results are as follows:

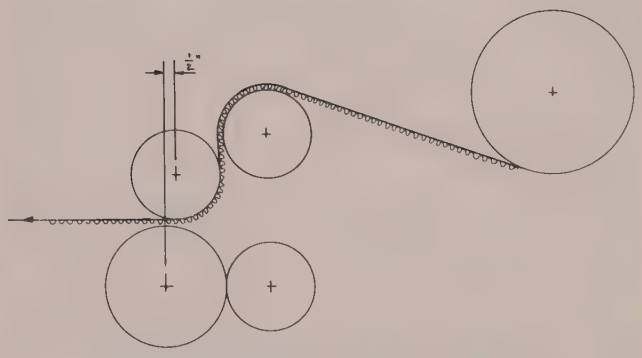

Fig. 2. LFC glue machine thread up

CONSTRUCTION

1. Rider roll set $^1/_2$ to $^3/_4$ in. back of center line of glue roll.
2. Rider roll has 0.010 to 0.012 crown on o.d. 85 in., 0.015–78 in.
3. Rider roll to be of heavy stiff construction (6 or 7 in. o.d.) and heavy duty bearings with no play.
4. Spreader roll set back of and about 5 in. higher than rider roll, to give about 35° wrap on rider roll.
5. Spreader roll must be hung on same arms as rider roll.
6. Spreader roll bracket on front side should have vertical and horizontal adjustment to level single-face pull.
7. Spreader roll has $^1/_8$ in. crown on o.d. Not critical.

OPERATION

1. Thread-up over spreader roll and under rider roll This accomplishes:
   - A. Spreader roll knocks any large bows out of paper.
   - B. Wrap on rider roll snugs single face around roll for a smooth even travel. Small waves or ripples, which are one of the common causes of "double-back skips," are virtually eliminated.
   - C. Opens flutes up for equal opportunity glue application.
   - D. Crown on rider roll gives even pressure across single-face web.
   - E. The "pull down" on spreader roll is twice the "pull up" under the rider roll, so there is no "bounce."
2. Glue application.
   - A. Doctor roll setting is minimum 0.006–0.007 for normal operation. On W.P. starch, setting is opened to secure desired application.
   - B. Wrap or wipe of flutes over glue roll is approximately $^3/_4$ in.
   - C. Glue roll speed is in range of 100 f.p.m. 70%, 500 f.p.m. 90 to 92%.

RESULTS

1. Even application across the web along the flutes.
2. Application on the very tip of flutes.
3. Little or no slop or spray in flute valleys.
4. Edges dry—or as dry as center. Edge blanks look like center blanks as far as dryness. Center cuts look like edge cuts as far as glue pattern.
5. Usage is as economical as can be had consistent with type of 0.009 and considering *even* application across the sheet.
6. Weave of S.F. on thread-up is decreased.

All seven of our corrugators now have both the belt driers and the new glue roll thread-up. Those plants with two corrugators tried them out on one first before installing them on the second corrugator. In each case the plant personnel found the respective results helpful before proceeding with the second installation. We might say we had little or no

trouble with the belt driers as their operation was simple and the results immediate and apparent. The same was not true of the glue roll thread-up. In fact, some installations were put on and taken out as many as two or three times before the operating personnel became convinced of its merits. However, the main trouble with the glue machine thread-up installations was that on the older machines, the glue rolls and bearings were not in good enough shape to apply thin films of glue. In each instance of an installation on an older machine, these were completely reworked. This, in itself, is a very desirable thing.

As mentioned before, we now find that often our edges are drier and glued tighter at the end of the corrugator than the center of the sheets. This, we think, is due to the fact that we are now able to dry the edges better plus the fact that we are no longer putting excess glue on the edge sheets in order to get an acceptable pattern in the center. We do not claim exceptionally low glue spreads and costs, but we are utilizing the glue better by putting it uniformly along and on top of the tip. The fact that we are no longer "flooding" the edges with glue has contributed to the elimination of wet edges and substantiates the discarding of the old assumption that wet edges were due to flow of moisture outwards from the center along the flutes. We are sure that any corrugating superintendent or corrugating foreman would be very happy to have the uniform glue patterns with more consistent dry edges that these two new tools provide if they had their "druthers."

We have also installed the tapered glue roll drive, to compensate for speed changes, on all seven corrugators, and would not be without them.

In summary, we have found both to be very helpful to our operation but neither one is a cure-all. We still have some hi-los and we still have some warp, but it is very much better than it was a few years ago. We are able to run at higher speeds, with less glue than formerly used, and with a satisfying reduction in warp.

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Automatic Slitter Alignment Savings

PHILLIP ZIEGLER

If you are operating a typical 85-in. corrugating unit, you are losing between 1 to about 2%* of all the board run over your combiner as side trim. Translated into dollars based on an average weekly production of 10 million square feet, this waste amounts to well over $50,000† per year. At Fort Wayne Container Division of St. Joe Paper Co. our automatic web control at the slitting and scoring stations currently saves over $2800‡ per year in trim reduction alone, without taking into consideration the sheets which would have to be scrapped due to "trim loss."

Contrary to what may be expected, this is the most tangible but least significant advantage of our slitter alignment control. Preceding my employment with Fort Wayne Container Division of St. Joe Paper Co., it was decided that the new proposed corrugator installation would include a tandem triplex installation. Increased operating speeds reducing available slitter setup time warranted this. Further, it was decided that if a suitable slitter control device could be developed, the two triplexes could be used simultaneously. This would eliminate some subsequent operations involving scoring and slitting placement limitations. These items instigated our company's negotiations with Langston for the development and installation of a slitter control mechanism which would control trim and have the two slitters track with the accuracy required for slitting and scoring on two separate shafts of two different slitters.

The proposed new corrugator installation was to be furnished with a slitting, scoring, and web-alignment setup which would fulfill the following objectives:

1. It had to react and move fast enough to not lose the strip of trim with changing web conditions at any doublebacker speed.
2. It had to accurately track the sensing head without drifting and have no lag.
3. It had to move to eliminate inaccuracies with web warpage and shrinkage at different speeds and standstills.
4. Hunting had to be minimized if not altogether eliminated.
5. In the event the board web was broken or severed, the slitters and sensing device had to remain in position until reset or it sensed a new web.
6. Manual adjustment had to be provided to instantly override the automatic alignment system.
7. Equipment had to be simple, rugged, and require minimum maintenance.

Our tandem slitter arrangement probably presents the most difficult circumstances that can be encountered for a control of the type I am going to discuss. While I appreciate that there are many methods of web alignment available in proc-

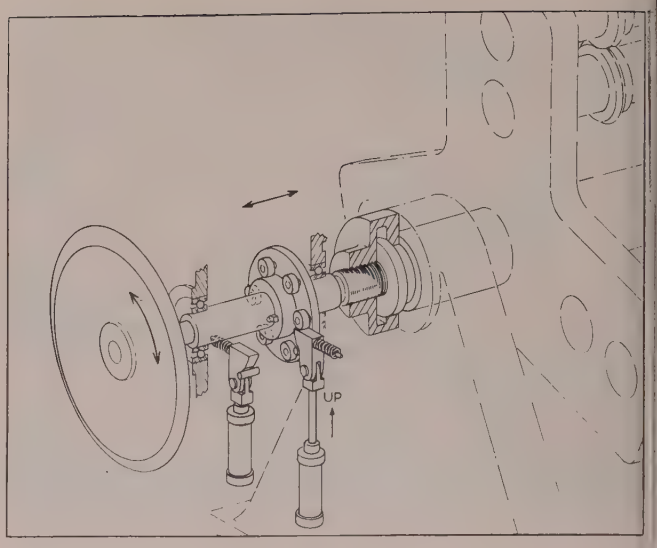

Fig. 1

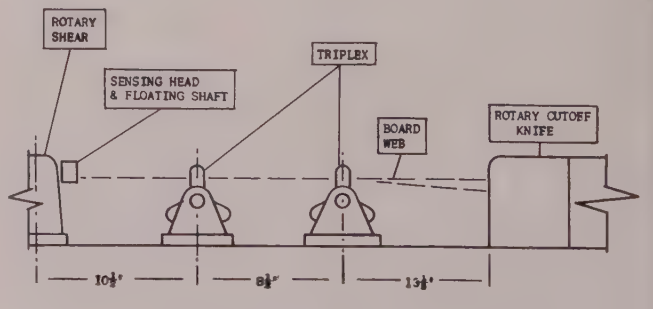

Fig. 2. Automatic web alignment control layout schematic

Phillip Ziegler, Hartford City Plant Engineer, Fort Wayne Container Division, St. Joe Paper Co., Fort Wayne, Ind.

* Assume max. of 1 1/2 in. and min. of 3/4 in. Assume av. paper width of 80 in. 1.5 + 80 = 0.0187 (2%). 0.75 + 80 = 0.0093 (1%). (This goes to high side as 1 1/2 in. may not be absolute max.)

† 126,000 sq. ft./hr. × 10 hr./day = 2,016,000 sq. ft./day. 2,016,000 sq. ft./day × 5 days/week = 10,080,000 sq. ft./week. 10,080,000 sq. ft./week × $10.00 MSF = $100,800/week. $100,800/week × 50 weeks/year = $5,040,000/year. $5,040,000/year × 1% trim waste = $50,400/year trim waste.

‡ Reduced min. from 3/4 in. to 5/8 in. keeping max. at 1 1/2 in. Av. at 3/4 in. = 1 1/8 in. Av. at 5/8 in. = 1 1/16 in. 1 1/16 + 1 1/8 in. = 5.57% (5.6%). 50,000.00 × 0.056 = $2800.00.

esses of other industries, some specialized and some standard, and at least one other type even for this application, for the sake of brevity I would like to confine the discussion to that tried in our plant. The entire research involved in our trial was almost exclusively conducted by the Samuel M. Langston Co. It is with their approval and cooperation that I relate the details of our experiences.

Unlike most conventional methods of automatic controls, the sensing element does not feed back information (Fig. 1). The relative location of the sensing head and two slitters is shown. The sensing head precedes the slitters and is located on a bar mounted to the rotary shear between the double-backer drive pully and the slitter. Our particular unit is also hydraulically operated. The motor-driven hydraulic unit connects the two slitters and the sensing element but the actual control in the hydraulic system is electrically operated.

Let's follow the sequence of operations before getting into the mechanical details to provide a better general idea of the principle of operation of the system.

1. The sensing head follows movement of the web.
2. This movement is electrically transmitted to solenoid operated valves in the hydraulic system.
3. This simultaneously permits the pistons actuating the sensing element and the slitters to make one complete stroke. This one stroke moves the sensing element shaft and the two slitter shafts, $^1/_{24}$ in.
4. If the sensing element is not yet in the neutral position, the cycle is repeated.

The actual start-up of our web alignment system is as follows:

1. The hydraulic motor pump unit is started.
2. The sensing element floating shaft is located in its mid-travel position with the handwheel. This travel distance is exactly the same as the cross travel distances of the slitters.
3. The sensing element is then adjusted so that the edge of the web is in its midcross travel position.
4. The slitter's cross travel position is located by moving the handwheel manually positioning the slitter to the desired amount of trim.
5. The separate switch controlling the sensing head is turned on. The head thus locates itself properly with respect to the web edge.
6. The selector switch on the slitter or slitters is then moved to the "On" position and the web alignment is in operation.

Putting the automatic web alignment into operation takes less than 30 seconds, all of which can be internal to run.

The construction which is used in our Langston web alignment mechanism is shown on Fig. 2. Rather than a modulated sliding movement, a step actuation is used to positively avoid out-of-step drifting. This is accomplished by means of two hydraulic cylinders, one for each direction of adjustment. With every full stroke of one or the other cylinder, a disk with 6 evenly spaced cam followers is advanced $^1/_6$ of a turn. This would leave the cams in the same relative position they are now, ready to receive a stroke from either of the two pistons.

This cam disk is pinned to the lateral adjusting screw. The large manual control handwheel is secured to this same lateral adjusting screw. The effect of one hydraulic stroke is exactly the same as moving the large handwheel $^1/_6$ of a revolution.

This lateral adjusting screw has four threads per inch, thus one cylinder stroke will result in a lateral movement of $^1/_{24}$ in. In the rest position of the adjusting cylinders the indexing pawls are in the retracted position and out of the way of the cam followers, so that manual adjustment is possible by means of rotating the handwheels without interfering in any way with the automatic indexing feature. This unit is identical for the floating arm of the sensing element and both slitters.

Manual movement of the slitters in no way interferes with the line-up between the edge of the web and the sensing head. The slitter travel would remain synchronized with the sensing head but it would be in a different position with respect to the web edge than the slitter head.

Electric, limit switch interlocks are provided to assure that all cylinders have completed their total working stroke before the next actuation takes place. This makes it impossible for the units to fall out of step. Limit switches are also provided to avoid overtravel of the total lateral adjustment in any direction. The hydraulic power unit supplying fluid to the actuating cylinders can actuate up to 60 strokes per minute, which is equivalent to a total movement of $2^1/_2$ in. per min. We found through experience that a speed of 42 strokes per minute or $1^3/_4$ in. of travel per minute gives us the optimum operating condition.

As would be imagined, there were many problems encountered and solved leading into the development of the system as outlined. Mainly, these concerned the operating speed of the web alignment device, time lag between response of the two slitters and a drifting out of phase of one slitter with respect to the other over a period of time.

To correct these difficulties Langston supplied a new larger hydraulic unit of 5 hp. as compared to the original 3-hp. unit. This also increased the available operating pressure. Limit switches were installed that are actuated from the hydraulic piston rod and permit starting of a new stroke immediately upon completion of a stroke. They replaced the time delay relays and lock the operation of the slitters together. Now, one complete cycle has to be completed before another physical movement of any part of the cycle can be started. A combination of these two corrections plus increased hydraulic capacity and pressure acted to more than double the operating speed.

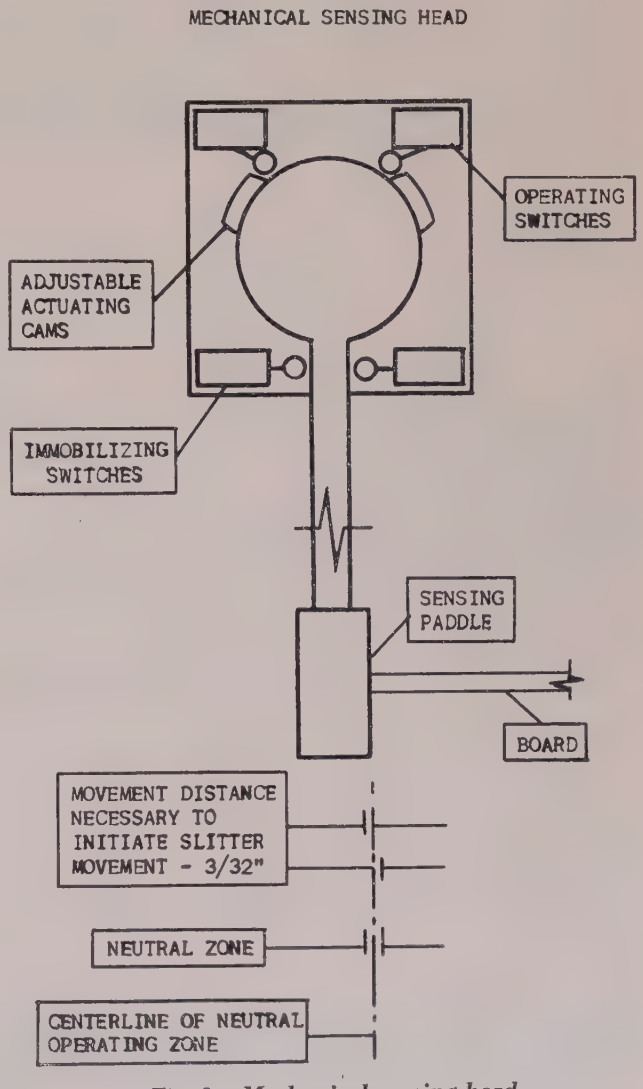

Fig. 3. Mechanical sensing head

The larger hydraulic system had made possible faster acting of the transverse slitter travel permitting more sensitive control. This permitted changing the lateral adjusting screw thread from three to the four threads per inch previously described. Now it takes 24 piston strokes to move 1 in. instead of the initial 18 and one revolution of the handwheel and swivel shaft only moves the cross travel of the slitter $^1/_4$ instead of $^1/_3$ in. The control accuracy was increased accordingly.

Initially, problems also resulted with clearance control and inertia. Inertia developed as a result of free wheeling, taking up lost motion, occasionally mislocating the cam. This frequently produced a missed stroke if the next stroke was reversed. The swivel shaft of the slitters was redesigned at the end which permitted control of clearances in the transverse travel of all end play except that in the thread.

The sensing heads themselves are almost another complete subject. With paper dust and sweating being major problems, it seemed logical to start with a purely mechanical element (Fig. 3). This had a paddlelike arm riding against the paper web. The movement of the web altered the paddle position which in turn operated limit switches from the cams as shown on the slides. Our maintenance supervisor made several modifications to this and we gradually obtained the $^3/_{32}$ in. control as shown. We also added the immobilizing switches so that the control movement was eliminated under certain conditions.

Next, Langston tried an air sensing head but this did not produce the accuracy required.

In all I believe we tried five sensing devices before we arrived at the most satisfactory control, the photoelectric system.

This consists of a light source located above the paper, transmitting a light down to a photocell receiver. The output signal of this photocell actuates a single selfcentering relay through a selenium rectifier, thereby avoiding electronic tubes.

A mechanical electric schematic of this is shown in (Fig. 4).

To overcome the dust problem, the head has been designed to let any paper particles pass freely through the head mounting and a small air jet is provided to keep both probes permanently clean during operation (Fig. 5).

The sensitivity of the head can be varied by changing the distance between the light source and the photocell.

Although the photoelectric eye is capable of very close limits of control, we have found that a sensitivity of around $^1/_{16}$ in. in keeping with the $^1/_{24}$ in. correcting stroke reduces overstroking or hunting. I have been informed that the newer sensing head, also carrying a secondary photoelectric system, located 2 in. inside the web automatically locks out the control in case of tear-out or interruption of the web.

The throat adjustment and guide provide little interference with paper slices and threading, yet keeps the web close enough to the base to maintain accurate control. It becomes obvious here that the lineup of the single-face web and doublebacker liner at its entrance into the doublebacker hotplates is more critical than ever if the slitter control is to produce the desired results.

Looking back over a 6-month operation of our automatic slitter alignment and tandem slitting and scoring operation, beside actual trim savings other tangible advantages have been realized such as;

1. This simultaneous use of tandem slitters with the automatic web control eliminates many additional subsequent sheet fed slitter operations.
2. Planning can be facilitated by permitting a particularly long order to be pooled with several orders and perhaps even a different paper width to trim out the corrugator width. It is made feasible two ways: (a) duplication of part of the setup on another set of shafts, and (b) setting up the long run on the operator side of one triplex and varying the other setup on the second triplex to make up the composite web width.
3. Less waste is encountered due to untrimmed sheets. In the event the board web shrinks less than the pooling width, the web alignment maintains one trimmed edge.
4. Less attention is required on the part of the slitter operators once the controls are set for a given amount of trim. The slitters track and maintain the constant flow of trip up the collector system.

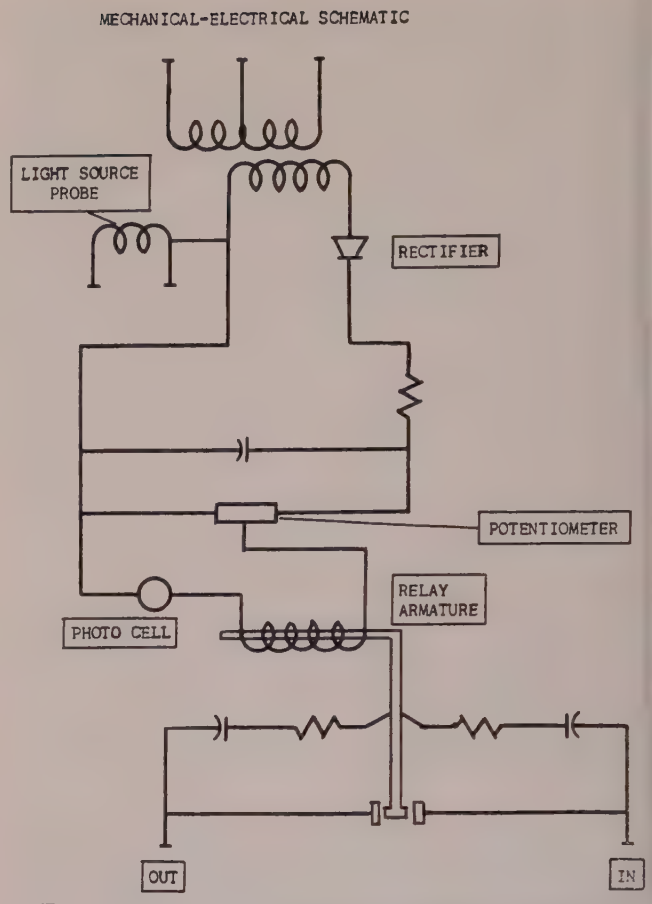

Fig. 4. Mechanical-electrical photohead schematic

Our experience to date has proved that we can track close enough to use $^1/_2$§ minimum allowance for pooling but in most cases should have about $^5/_8$ in. It requires close paper alignment at the single-facer and glue machine to take full

§ With narrow paper widths (under 60 in.) and pads we have operated successfully with $^7/_{16}$ in. trim. Other conditions such as score take up, poor roll edges, and excessive shrinkage, etc., dictate against going to the lower limit as standard. The $^1/_2$ in. limit is used where the alternate choice is the next higher increment in roll stock.

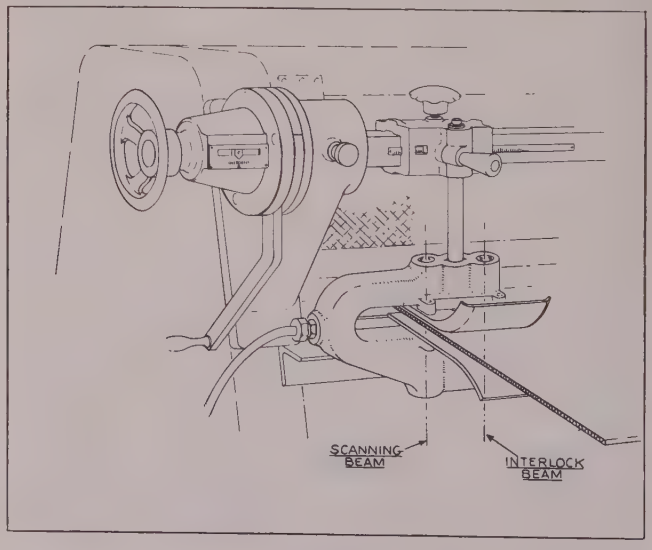

Fig. 5

advantage of this reduction. Further, on some grades shrinkage at different operating speeds may reduce the actual trim to zero at the opposite side of the web from the control element. The amount of scoring, paper width, grade and moisture, speed, and doublebacker heat control affect this.

Here are two typical readings.

	1	2
Width of paper	85 in.	79 in.
Number out	3	4
Theoretical width	$84^{3}/_{8}$ in.	$78^{5}/_{16}$ in.
Calculated trim	$^{5}/_{8}$ in.	$^{11}/_{16}$ in.
Actual measured trim (both sides)	$^{3}/_{8}$ in.	$^{5}/_{16}$ in.
Shrinkage & score takeup	$^{1}/_{4}$ in.	$^{3}/_{8}$ in.
Grade of board	175-C	200-A

Our investigation into reduction of trim was further complicated by the varying roll width. Until this study we always thought an 85 in. wide roll came in 85 in. This is not necessarily so. While it seldom ran less than the specified width, it frequently ran over, sometimes as much as a $^{1}/_{4}$ in. The man doing the pooling had no way of knowing whether he was trimming to $^{1}/_{16}$ less or a $^{1}/_{4}$ in. more than his calculations showed.

The actual shrinkage between the single-face liner, single-face web, and double-facer liner also varied. Unbalanced liners and operating conditions were the most prominent causes. This, plus doublebacker alignment again, effected the minimum trim with double wall. Another item of particular importance with double wall is the resistance caused by the combined board thickness to slitting. When the trim is lost, the slitter knives will push a narrow web between $^{1}/_{8}$ in. to about $1^{1}/_{4}$ in. over before the resistance of the web is great enough to force it into the knife. Then the web will move back to its normal position, and trim will be lost at the other side. A similar situation has occurred with some warped webs when this web is forced to arc downward between knives. While the same problems are experienced with manual operations, it is a significant factor effecting the minimum practical trim. In most instances with double wall runs, we do not gamble and stay with a $^{3}/_{4}$ in. total minimum trim.

A serious limitation when operating with only one slitting and scoring unit occurs when close slitting and scoring centers must be held. Special combination heads sometimes provide the answer, but this can only be economically justified for large orders. Machining down the width of the slitting and scoring heads introduces the serious problem of "wobble" and "runout" which substantially decreases scoring accuracy and the quality of the slit edge.

Our triplex units are tracking close enough to permit simultaneous scoring of the same blank on both pairs of shafts. This, unquestionably, affords a great advantage yet is almost impossible to evaluate. We have virtually no minimum scoring center problems at our corrugator. Flanged tubes of appliance cartons are an example of our best savings Then, too, when sheets are scored at the two triplexes, the board is less susceptible to cracking at the scorers. (Our production manager estimates with more experience we will be able to reduce our subsequent sheet fed slitting and scoring about 12%.)

Generally speaking, we are finding our automatic slitter alignment and tandem operation of two slitting and scoring units a most valuable tool is reducing waste and improving operations in our corrugating unit. This device has been fully accepted by our operating personnel, which indicates that it has passed the acid test.

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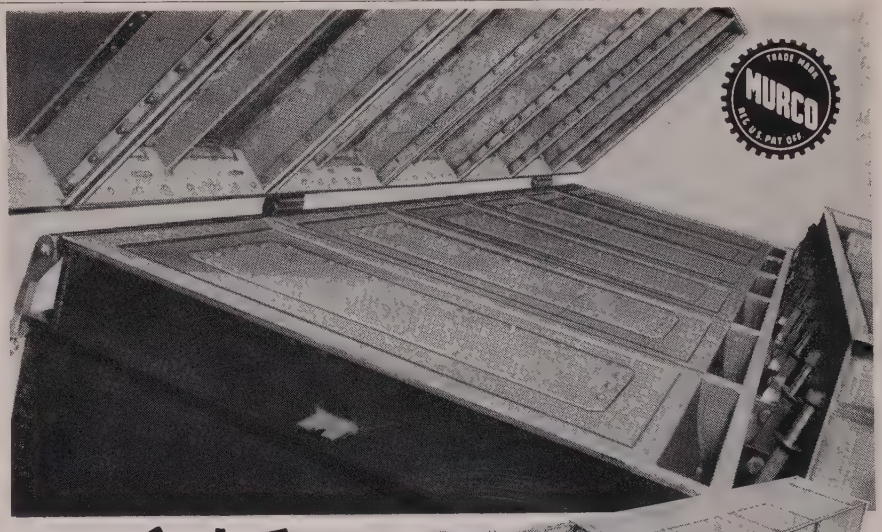

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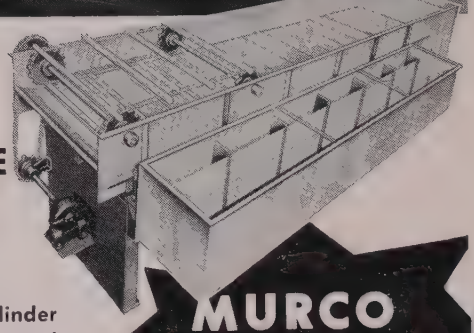

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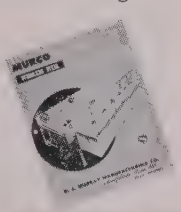

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Flotation Saveall Control Systems

GREG KLEBANOFF, JR. and
CHARLES G. BUELTMAN

THIS paper describes control systems successfully used to obtain best economical control of new flotation saveall installations, and to improve the performance of existing installations. These control systems are designed for one or all of the following purposes:

1. To save additional fiber or pigment currently being lost in the plant effluent. This is particularly important if the recovered stock is re-used.
2. To improve the clarity of the treated white water by removing more suspended solids, to enable its use in a higher priority function.
3. To decrease the pollution load if the white water is entering a public stream.
4. To decrease the number of man hours required for operation.
5. To minimize chemical feed dosages if such are used.

In order to provide a proper background for discussing the various controls, we will review briefly exactly what a flotation saveall is and does. First, a measured amount of air is introduced at the suction of the process pump and is dispersed by the mixing action of the pump impeller. As shown on Fig. 1, the mixture of white water and air enters a retention tank where the combination is subjected to pressure which forces air into solution. The white water, now containing dissolved air, is released to atmospheric pressure in the inlet compartment of the flotation saveall. When the pressure is released, air comes out of solution forming bubbles on the suspended solids present. The suspended solids tend to serve as "seeds" for the bubbles. The liquid then lays out over the surface of the flotation compartment. Clarified, or solids-free, liquid descends and is withdrawn from the bottom. Floated stock remains at the surface.

The floated stock is removed from the surface by means of continuously operating scraper blades which pass toward the rear of the unit, up a ramp, and into a sludge compartment from which it is withdrawn for re-use or disposal.

Clarified liquid leaves the bottom of the flotation compartment through a series of collector tubes designed for uniform drawoff throughout the bottom area, and up through risers which discharge into the clarified water compartment. Clarified water then flows out of the clarified water compartment over a weir. From the downstream side of the weir the clarified water is pumped, or fed by gravity, to a point of re-use or is discharged directly to a receiving stream.

PRESSURE CONTROL

Reliable control of operating pressure is important for maximum efficiency. The control system should be arranged so that the full pressure drop is realized just prior to the white water entering the inlet compartment.

Figure 2 illustrates two systems for obtaining this pressure drop. A, the upper sketch, illustrates one method of employing a pressure regulator installed in the floor of the inlet compartment. Often, because of mechanical features of the regulator, it is not possible to get the full pressure drop at this point. The necessary amount of pressure for optimum efficiency is determined by the amount and character of the suspended solids. If the suspended solids content is great, or if the solids are heavy or numerous such as with titanium dioxide, a high pressure in the order of 50 to 100 p.s.i. is needed to dissolve the necessary amount of air in order to get enough bubbles. In such a situation, some form of auxiliary valving arrangement is included prior to this point to kill off a portion of the pressure. This means that there are two major pressure drops in the line. While the action that takes place under this condition has never actually been observed, a plausible theory, based on improved results obtained with the alternate method, is this:

At the first pressure drop, air bubbles come out of solution and begin enlarging. At the second pressure drop, more air comes out of solution and enlarge the bubbles further. The end result is fewer air bubbles. A probable secondary action at this point, which would adversely affect efficiency, is that bubbles, which have already formed on suspended solids particles, are sheared off by the turbulence.

In the lower sketch, B, there is one pressure drop which remains constant regardless of the variations in flow. This second technique insures a smaller bubble, and consequently more of them—lessening the probability of a suspended solids particles slipping through without becoming attached to an air bubble.

RECYCLE CONTROL

Recycle control is employed to even out changes in flow when a constant flow of white water is not available. This would occur when one machine is shut down for a grade change, or when a portion of the untreated white water is being used to fill a beater. Provision must then be made for the flotation saveall to follow variations in the flow. This can be accomplished as shown in Fig. 3.

A holding tank receives the white water. This tank is generally sized to hold approximately 10 min. of liquid at the design capacity, and has a constant cross section throughout the range of level control. White water from this tank is then pumped through the flotation saveall in the normal manner as previously described.

A level controller is used to position the recycle control valve. The level controller is adjusted so that, as the flow

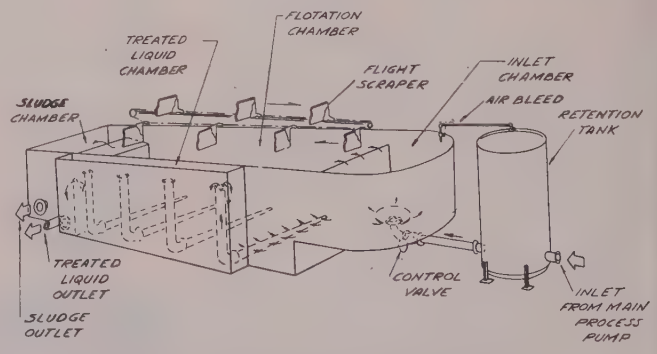
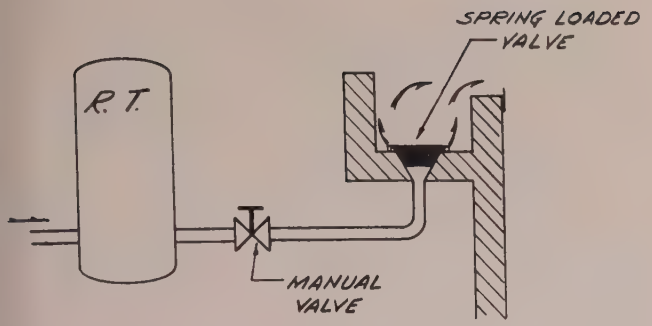
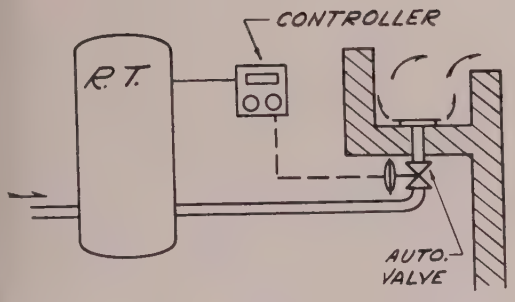


Fig. 1. Flotation saveall system

GREG KLEBANOFF, JR. and Charles G. Bueltman, Permutit Co., NewYork, N. Y.



A- 2-DROP METHOD



B- 1-DROP METHOD

Fig. 2. Pressure control

of white water to the holding tank increases, causing the level to rise, a changing signal from the level controller to the recycle valve throttles the recycle valve. More liquid now goes through to the flotation saveall.

Conversely, when the supply of white water to the holding tank decreases, its level drops and the level controller gradually opens the recycle valve. Recycling liquid maintains the holding tank level within the specified range. This range can be selected to suit plant conditions so that the flotation saveall is able to keep pace with changes in flow without upsetting its own operation—particularly if chemicals are being fed.

Proper pressure control is necessary to do this. To go back one step, the pressure control system previously illustrated can automatically compensate for changes in flow, and as a result, the same quantity of air, because of the constant pressure, is always dissolved in the liquid.

AUTOMATIC WEIR

Where there are wide fluctuations in flow rate and where the consistency of the stock being removed from the top of the flotation saveall is important, the degree of "bite" of the scraper blades is critical.

The collector tubes can be set at a median range for most applications, so that sufficient sludge, at low throughput and consequent low level in the flotation compartment, is adequate. At higher flow rates, the level will be somewhat higher and the depth of "bite" will be proportionately greater. This is because of the gushing effect of the water as it leaves the risers. At higher flow rates, the spout action will raise the liquid higher. The difficulty with this arrangement is that, at the higher throughput, the increased amount of water being removed with the sludge may be detrimental.

To automatically compensate for such a condition, an automatic, patented, device has been employed.

Figure 4, in the upper left corner, shows the conventional

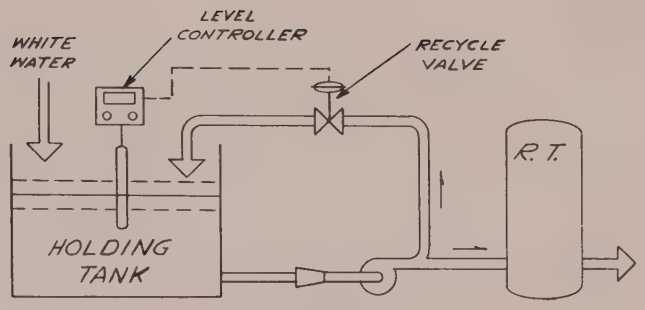


Fig. 3. Flow control

or standard method of passing the clarified liquid through risers and discharging this into the clarified liquid chamber. The alternate would be to lower each of the riser sleeves below the discharge weir so that they are submerged and hence can no longer control the level.

The rest of Fig. 4, shows what is then substituted to maintain a constant level in the flotation compartment.

A standard level controller "feels" the location of the level in this compartment—which corresponds to the level in the flotation compartment. The controller sends an air signal to an air motor which provides the power, through a mechanical link, to position a movable weir accordingly. In this manner, a constant level is maintained and the amount of sludge removed by the blades is accordingly varied with requirements.

The action just described can be visualized by picturing a bathtub filled with fresh beer. Suppose we are interested in removing the suds only. Since the density of the suds is considerably less than that of the liquid, they will float on the surface. The blades would be required to be held at the surface of the liquid. Anything above this surface will be removed by the blades. Although floating stock is denser than beer suds, the simile is true for the operation of a flotation saveall. As long as the level is held steady, the proper amount of sludge will be removed, since it will build up above this level.

PROPORTIONAL CHEMICAL FEED CONTROL

Again, with variations in the flow rate, the amount of chemicals, if any, that are being fed, should vary proportionally.

Rather than employ the use of a pipe-line flow measuring instrument, which will transmit a signal in accordance with flow rate variations, we use the level controller already installed on the holding tank.

If the range of this instrument is reasonably wide, approximately 2 ft., the output signal from the level controller will vary, roughly, in proportion to the throughput of the flotation unit. We should review again the operation of this level

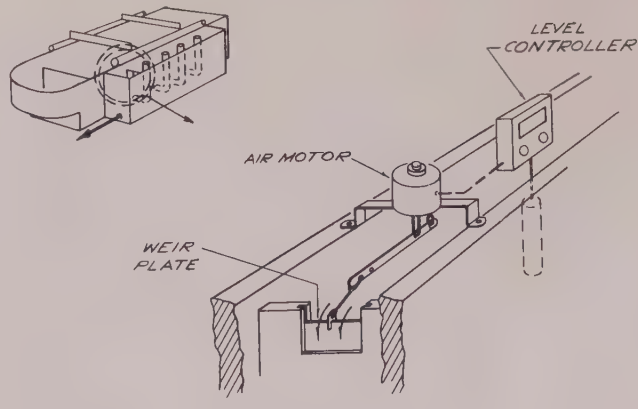


Fig. 4. Automatic weir

controller, which is designed to position a recycle valve to maintain a constant level in the holding tank. We have already established that, in order to eliminate shocks or surges, the control range should be reasonably wide. Approximately then, the location of the level in the holding tank will indicate what the throughput to the saveall is. At low levels, the throughput will be small, because the recycle valve is permitting more liquid to come back to maintain this level. When the holding tank level is high, the throughput will be great because the recycle valve is throttled.

If this same signal, which is now going to the recycle valve, is delivered to a stroke-adjusting positioner on a positive displacement pump, the positioner will vary the stroke in accordance with the signal. If more than two chemicals are being fed at the same time, the proportion, or ratio, between them will be constant even though the quantity varies.

Such a system, using a positive displacement pump as compared to gravity chemical feeding, enables the injection of chemicals at a point of high pressure, which is almost always required for the proper formation of a floatable floc.

While these control systems are not expected to cure all ills that may be encountered in the operation of a particular flotation saveall, they are almost certain to improve the performance, and can be employed using standard mass-produced components at a small expense.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 23–26, 1959.

Water Conditioning Trends in the Paper Industry

S. B. APPLEBAUM and CHARLES B. HOUSER

CONTINUOUS growth and expansion of our pulp and paper mills has been reflected in a sharp rise in power generation requirements.

The increased volume of steam required for power and process purposes has involved larger boilers of increasing pressure. In the public utility field, boiler pressures have gone up above 2600 p.s.i. and in some cases, above the supercritical range, viz., 3250 p.s.i. In the pulp and paper industry, the boiler pressures have also increased and recent modernization plans have included boilers of well over 1000 p.s.i.

These larger and higher pressure boilers necessarily involve a much greater investment. They also call for a higher quality of boiler feedwater, to protect them from shutdown due to scale or corrosion and to ensure proper purity of steam for turbines.

In many mills, there is a considerable prior investment tied up in existing feedwater treating equipment. The operator, in planning his expansion program, is therefore faced with trying to utilize existing equipment as much as possible and yet produce the higher quality of water required.

This paper will describe three case histories of prominent pulp and paper mills who have been faced with this problem and will show how they solved it. One mill selected hot lime zeolite, the second a desilicizer, and the third, a demineralizer. The studies made in each case of the alternative methods of water treatment considered, including comparative operating cost and investment, will be given, as well as the reasons which dictated the selection of one particular method. Prominent design features of the equipment installed will also be illustrated.

IMPURITIES IN FEEDWATER TO BE REMOVED

The main impurities to be removed by these water treatment plants are:

S. B. APPLEBAUM, Director, Water Treatment Division, and CHARLES B. HOUSER, Project Manager, Cochrane Corp., Philadelphia, Pa.

Table I. Silica Tolerance versus Boiler Pressure to Produce Steam Containing Less than 0.02 to 0.03 P.p.m. SiO_2

Boiler pressure, p.s.i.g.	*Silica in concentrated boiler saline, p.p.m.*	*Silica in feedwater for 20 concentrations or 5% blow-off, p.p.m.*
<600	35 to 50	1.5 to 2.5
700	25 to 35	1.0 to 1.8
800	15 to 20	0.8 to 1.0
900	8 to 10	0.4 to 0.5
1000	5 to 8	0.3 to 0.4
1250	3 to 5	0.2 to 0.3
1500	2 to 3	0.1 to 0.2
2000	0.8 to 1.2	0.04 to 0.06

1. *Hardness.* As boiler pressure increases, the hardness should be reduced to zero to prevent scale deposits, due to calcium and magnesium.

2. *Alkalinity.* Reduction in alkalinity is necessary to insure good quality of steam by avoiding carry-over and to prevent return line corrosion due to carbon dioxide in the steam.

3. *Total Solids Reduction.* This is desirable to reduce boiler blow-off.

4. *Silica.* As boiler pressures increase, silica will not only deposit in the boilers but will also deposit hard glassy scale in the turbines. This reduces turbine efficiency and calls for expensive outages for cleaning. The only way to prevent such turbine silica deposits is to reduce the silica content of the steam to negligibly low figures (under 0.02 to 0.03 p.p.m.). This can only be accomplished by reducing the concentration of silica in the boiler. To avoid excessive blow-down when the silica in the feedwater is high, it is therefore necessary to reduce this silica in the make-up.

Table I gives the usual range of silica allowable in the concentrated boiler saline to keep the silica in the steam below 0.02 p.p.m. and the corresponding silica in the feedwater with 20 concentrations or 5% blow-off.

5. *Removal of Oxygen.* This is necessary to avoid corrosion. It is accomplished by deaerating heaters.

THREE AVAILABLE WATER TREATMENT PROCESSES

To accomplish reduction of these impurities, three prominent methods are available:

1. *Hot Lime Zeolite.* This will reduce the hardness to zero, alkalinity to 20 to 25 p.p.m., and silica to about 1 p.p.m. It has the advantage of versatility in handling variations in raw water composition and particularly waters not entirely clear. Hot lime zeolite plants have been installed for boiler pressures up to 1500 p.s.i. (*1*). However, in most cases when boiler pressure exceeds about 1000 to 1250 p.s.i., the trend is toward demineralization.

2. *Demineralization.* This not only eliminates hardness and alkalinity but reduces all of the total dissolved solids or electrolyte down to trace amounts. Mainly, however, it can remove silica to as low as 0.02 p.p.m. or less. In many cases of medium and high pressure boilers, the concentration of silica will control the amount of boiler blow-off and if the silica in the raw water is sufficiently high, reduction in silica below the limits of 1 p.p.m., usually obtainable by hot lime zeolite, becomes necessary. Demineralization has made rapid progress because of its particular ability to remove silica to negligibly low figures.

3. *Desilicizer.* This is a relatively new method of reducing silica without demineralizing (*2*). It is a compromise between hot lime zeolite and demineralization for silica removal.

Demineralization is a two step process: (1) The cation resin exchanges the cations for hydrogen, thus converting the salts to their corresponding acids. (2) The anion resin in the second step then adsorbs these acids or exchanges the acid radical for hydroxide, thus producing almost pure water. However, the strongly basic anion resin is also capable of splitting the salts directly, exchanging the anions for hy-

droxide without going through an acid regenerated cation resin first step. Thus, all the salts including silica are converted to sodium hydroxide. Some acid is usually added as a final step to convert part of the hydroxide to sulfate to control the ratio of alkalinity of total solids to 1 to 4.

Desilicizers can reduce silica down to 0.1 to 0.5 p.p.m. with less caustic soda for the regeneration of the anion resin than required for demineralization. It, therefore, involves a lower operating cost. Furthermore, the equipment is less expensive because it is not necessary to use rubber-lined piping, valves, and shells, as is the case with demineralization. All that is required is to soften the water through cold sodium zeolite and then pass the soft water through unlined anion units. Several of these salt splitter desilicizers are now in successful operation and one of them is described in this paper.

We will now discuss the three case histories which will exemplify the reasons for selection of hot lime zeolite, desilicizer, and demineralizer, respectively.

Plant A—Hot Lime Zeolite

This large paper company, located in Pennsylvania on the Great Lakes, is noted for the manufacture of very high grade quality paper. About 20 years ago, they installed a hot lime soda softener, having a capacity of 160,000 lb. per hr.

With their continued growth, in 1945 they installed a new larger hot lime soda sedimentation tank and the old smaller tank was used for phosphate secondary treatment in series with the first tank. This permitted reducing the hardness to almost zero by phosphate precipitation in the second tank.

In 1957, when further expansion was required and a modernization program was studied, four possibilities were considered: (1) to discontinue the existing hot process equipment and install a 450,000-lb. per hr. demineralizer; (2) to continue the operation of the present hot process plant unchanged, but add a 150,000-lb. per hr. demineralizer; (3) abandon hot process and install cold zeolite followed by acid and a decarbonator; (4) change the existing system to hot lime zeolite and abandon the use of phosphate in the second sedimentation tank. Both tanks would then be employed in parallel, adding filters and hot zeolite units and a new external deaerator after the zeolite.

The investment for either the first or second possibilities was much higher than for the other two. The third scheme would not reduce silica at all. In the future, when higher pressure boilers might be installed, silica reduction would be necessary. Furthermore, the third scheme would increase

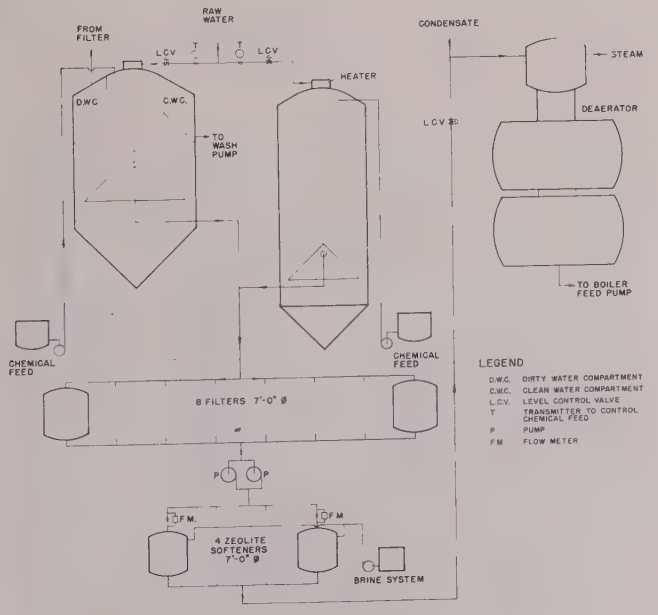


Fig. 1. Capacity 450,000 lb./hr., Plant A, hot lime zeolite

Table II. Plant A—Hot Lime Zeolite—Comparative Equipment Costs and Chemical Operating Costs

Equipment Costs

1.	Complete demineralizer, 450,000 lb./hr.	$250,000
2.	Partial demineralizer, 150,000 lb./hr.	120,000
3.	Cold zeolite plus acid and decarbonator	45,000
4.	Four hot zeolite units and one filter, etc., to supplement existing hot process equipment	57,000

Operating Costs

		Cents per 1000 gal.	*Dollars per year (300 days)*
1.	Demineralizing (acid and caustic)	12.6	$50,000
2.	Cold zeolite plus acid (salt and acid)	4.3	17,000
3.	Hot lime zeolite (lime and salt)	1.8	7,000

chemical operating cost by about $10,000 per year and involve handling acid. Therefore, it was decided to adopt the fourth scheme, viz., hot lime zeolite.

Table II gives the comparative operating cost of hot lime zeolite and demineralization and the equipment costs.

Table III gives the comparative chemical operating results.

Figure 1 is the flow diagram of the hot lime zeolite plant finally selected, for a capacity of 450,000 lb. per hr. The boiler pressure is 650 p.s.i. and the per cent make-up is over 50%. The deaerating heater was installed for a capacity of 880,000 lb. per hr. for the peak evaporation.

Plant B—Sodium Zeolite and Desilicizer

This is a paperboard plant located in Georgia. The boiler pressure is 600 p.s.i. and the usual make-up 33%. However, the water treatment plant finally installed had a capacity of 300,000 lb. per hr., which is a 50% make-up.

About ten years ago, this plant installed a hot process softener in which the hardness was removed by phosphate and caustic soda. The hardness in this supply is fairly low but the silica is high. To reduce the silica, magnesium salts were added.

In 1957, the plant was found to be too small for their requirements and the sedimentation tank of the original hot process plant had become damaged so that a new and larger sedimentation tank would have been required to continue hot process.

Several possible schemes were considered: (1) hot lime zeolite, (2) demineralizer, and (3) cold sodium zeolite softening plant followed by a desilicizer.

Table IV gives the comparative equipment cost and chemical operating cost and Table V the chemical results. Figure 2 shows the flow diagram.

The desilicizer was selected in this case because: (1) lowest over-all investment, especially when considering field erection

Table III. Plant A—Hot Lime Zeolite—Comparative Chemical Results in Parts per Million as $CaCO_3$

	City water	*After demineralizing*	*After cold zeolite and acid*	*After hot lime zeolite*
Calcium	95	0	0.5	0.5
Magnesium	32	0	0.5	0.5
Sodium	6	1	132	68
Total cations	133	1	133	69
Bicarbonate	83	0	15	0
Carbonate	0	1	0	27
Hydroxide	0	0	0	0
Sulfate	19	0	87	16
Chlorine	31	0	31	26
Total anions	133	1	133	69
Hardness	127	0	1.0	1
Alkalinity	83	1	15	27
Silica	1.5	0.02	1.5	1.0
Total solids	150	1	170	80

Table IV. Plant B—Desilicizer—Equipment Costs and Chemical Operating Costs

Equipment Costs (Not Erected)

1.	Hot lime zeolite (K.D.)	$ 80,000
2.	Demineralizer	102,000
3.	Cold zeolite and desilicizer	72,000

Chemical Operating Costs

		Cents per 1000 gal.	*Dollars per year (300 days)*
1.	Hot lime zeolite (lime, salt, and magnesium oxide)	4.5	11,000
2.	Demineralizer (acid and caustic soda)	10.6	28,000
3.	Cold zeolite plus desilicizer (salt and caustic soda) (liquid)		
	(a) With full amount of H_2SO_4	8.1	20,800
	(b) With small amount of H_3PO_4	7.7	19,700

of sedimentation tank, insulation, steam and other piping, etc.; (2) saving of space; (3) simplicity of operation—no chemical feeds; (4) capable of handling the extremely variable loads prevalent in this plant (with hot process there was danger of sludge carry-over from the sedimentation tank with these violent variations); (5) lower silica than hot process, also much lower carbon dioxide in steam.

As the flow diagram and chemical results sheet indicate, the acid feed installed was intended for the use of sulfuric acid to neutralize most of the alkalinity so that the ratio of alkalinity to total solids in the treated water would be about 1 to 4. However, during the last year of actual operation, in accordance with the instructions of the consulting engineer who regulated the tolerances of the various constituents in the concentrated boiler saline, the full amount of acid was not used. Instead a small amount of phosphoric acid was employed merely to introduce sufficient excess phosphate in the feedwater to maintain about 40 p.p.m. of phosphate in the saline. Table V gives the operating results as originally intended with the full amount of sulfuric acid in column 4 and the actual results obtained with small amounts of phosphoric acid in column 5. In column 6, the limits of the various constituents being maintained in the boiler are shown. This

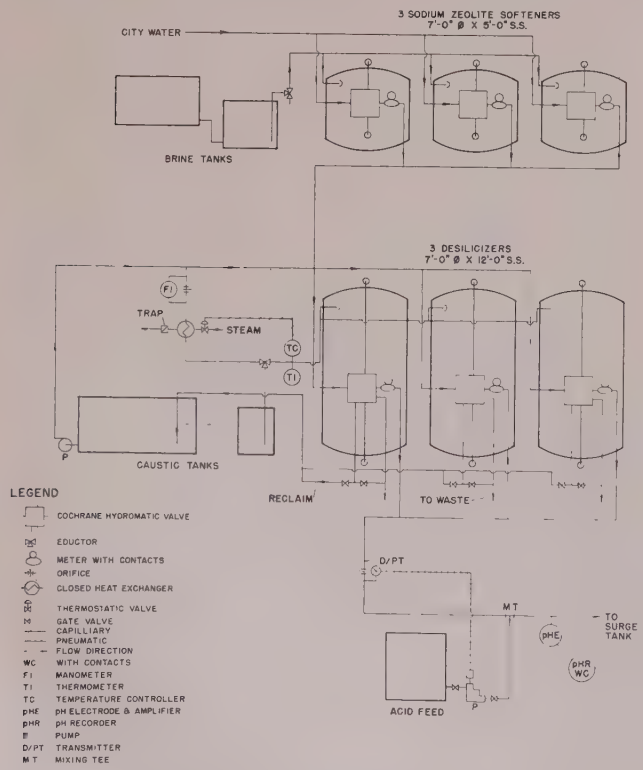


Fig. 2. Capacity 300,000 lb./hr., Plant B, sodium zeolite and desilicizer

Table V. Plant B—(Desilicizer)—Comparative Chemical Results in Parts per Million as $CaCO_3$

	City water	*Hot lime zeolite*	*Demineralizer*	*Sodium zeolite and desilicizer and full amount of sulfuric acid*	*Sodium zeolite and desilicizer with small amt H_3PO_4*	*Actual concentrated boiler saline*
Calcium	34	0.5	0	0	0	
Magnesium	11	0.5	0	0	0	
Sodium	12	54	2	57	57	
Total cations	57	55	2	57	57	700
Bicarbonate	30	0	0	0	0	
Carbonate	0	32	2	2	2	
Hydroxide	0	0	0	13	50	
Sulfate	19	16	0	41	0	
Chloride	8	7	0	1	1	
Phosphate	0	0	0	0	4	40
Total anions	57	55	2	57	57	700
Hardness	45	1	0	0	0	0
Alkalinity (M.O.)	30	32	2	15	52	450
Silica	13	1.5	0.05	0.6	0.6	6 to 10

is an interesting installation in showing that silica can be reduced to very low limits without demineralization.

As the flow diagram (Fig. 2) shows, the water treatment plant installed consists of three standard sodium zeolite units, 7 ft. 0 in. diam., regenerated with salt brine and followed by three strongly basic anion resin units, also 7 ft. 0 in. diam., regenerated with caustic soda. A tank is provided to reclaim some of the caustic rinsed from one regeneration, to be used as the initial step in the succeeding regeneration. Then fresh caustic follows. This saves some caustic soda.

To control the operations, each softener and anion unit is supplied by a meter and a hydromatic single control valve. This is illustrated in Fig. 3. It avoids a multiplicity of gate valves and by turning the hand lever on the small pilot valve to "backwash," "regenerate," and "rinse" positions on the dial, the regeneration is carried out correctly with a minimum of attention. This assures foolproof operation, by avoiding the opening and closing of many gate valves otherwise required with valve nests.

The paperboard mill operator is very well satisfied with the simplicity of operation compared to his previous experience with controlling the addition of a number of chemicals to properly precipitate the impurities and then settle and filter them out. Here no precipitates are formed. The reactions take place by ion exchange which has the great virtue of being automatic in its chemistry, avoiding over- or under-treatment.

This desilicizer process will make rapid progress for cases of medium pressure boilers where the raw water is high in silica, compared to the other solids. It is particularly economical in many plants where existing sodium zeolite

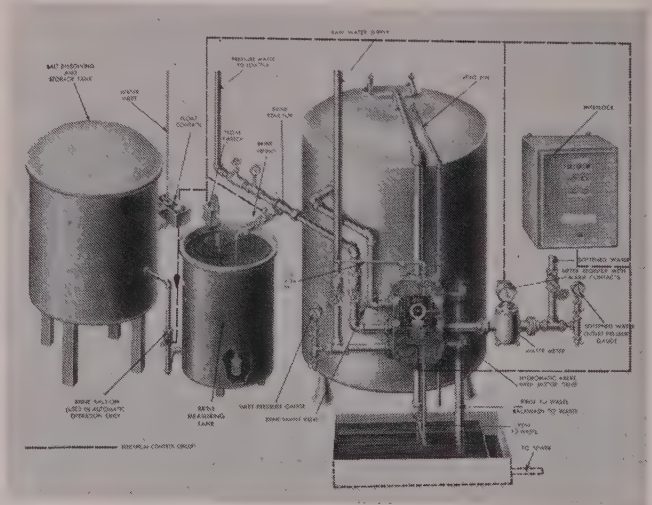


Fig. 3

Table VI. Plant C—Demineralizer—Comparative Equipment Costs and Chemical Operating Costs

Equipment Costs (Not Erected)	
Hot lime zeolite	$225,000
Clarification and demineralizer	310,000

Chemical Operating Costs	*Cents per 1000 gal.*
Hot lime zeolite (dolomitic lime, magnesium oxide, gypsum, and salt)	6.3
Clarification and demineralizer with reclaimed caustic (alum, lime, acid and caustic)	5.95

softeners are already installed because then only the anion units need be added to reduce the silica.

Plant C—Demineralizer

This is a large pulp company located in North Carolina. The water available is a polluted river supply. The make-up is 40% but when the condensate becomes contaminated, it rises to 100%. Boiler pressure at present is 650 p.s.i., but in the future plans are made to put in high pressure (1900 p.s.i.) boilers for topping turbines. The existing water treatment equipment consisted of a cold process coagulation, filtration, and cold sodium zeolite plant. Large quantities of ferric sulfate were added to reduce the silica from 15 p.p.m. down to 2 or 3 p.p.m. However, this greatly increased the sulfates in the treated water which caused high boiler blow-off. In addition, despite partial silica reduction, boiler tube failures occurred due to silica scale. As the plant expanded and boiler make-up requirements increased, the old equipment became overloaded and poor quality water in general was produced.

When a modernization and expansion program came up recently, the question of which type of water treatment process to adopt was studied in detail. Hot lime zeolite and demineralization were compared and Table VI gives the comparative investment and operating costs and Table VII the chemical operating results. Demineralization was selected because of the very low solids and silica it would produce to take care of the future 1900-p.s.i. boilers.

Figure 4 is a flow diagram of the clarification and demineralization plant now being installed. The demineralizer will have a capacity of 750,000 lb. per hr. initially, with room provided to add more units to increase the capacity to 1,000,000 lb. per hr. (2000 g.p.m.).

The river water being difficult to coagulate, a modern design of pretreatment equipment for clarification is included. This consists of two concrete rectangular coagulating solids-contact reactors, each designed for 1300 g.p.m., or 2600 g.p.m. total. The extra 600 g.p.m. will provide wash water for filters and demineralizers. Each reactor is 25 ft. wide by

Table VII. Plant C—Demineralizer—Comparative Chemical Results in Parts per Million as $CaCO_3$

	River water	*Hot lime zeolite*	*Clarification and demineralizer* — *Reclaimed caustic*	*Clarification and demineralizer* — *All new caustic*
Calcium	25	0–2	0	0
Magnesium	9	0–2	0	0
Sodium	24	109	2	2
Total cations	58	113	2	2
Bicarbonate	39	0	1.5	1.5
Carbonate	0	23	0	0
Hydroxide	0	0	0	0
Sulfate	10	82	0	0
Chloride	9	8	0.5	0.5
Total anions	58	113	2	2
Hardness	34	0–4	0	0
Alkalinity	39	23	1.5	1.5
Silica	16	1	0.1	0.05

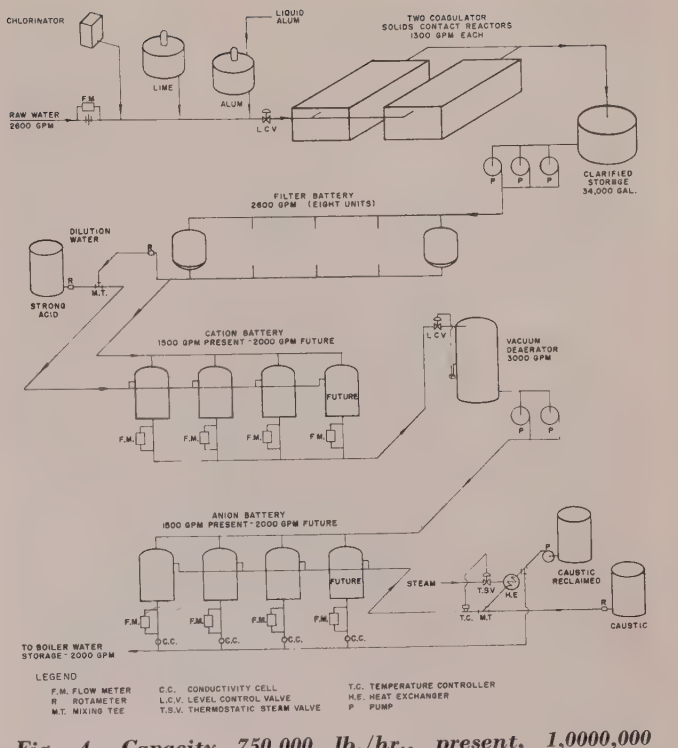


Fig. 4. Capacity 750,000 lb./hr., present, 1,0000,000 lb./hr., future, Plant C, clarification and automatic demineralizer

52 ft. long by 13 ft. high. Figure 5 shows a cross-sectional elevation which indicates the baffle structure and the horizontal shaft agitators running the full length of each unit. Chemicals flow by gravity into a baffled mixing trough that feeds the two reactors. Solution chemical feeds are provided for chlorine, lime, alum, and a coagulant aid, such as Dow Separan. The water, after receiving the chemicals, will flow into the longitudinal influent trough of each reactor from which the water is distributed through down-take pipes to the reaction zone below the baffles. The sludge blanket maintained in the bottom half of these reactors covers the baffle structure. The water after passing through the lower reaction zone flows through the central port and then laterally and horizontally over to the effluent flumes on the side walls. This contact with previously formed precipitates in the sludge blanket has a catalytic effect, producing excellent coagulation with a minimum of chemical and retention time. The horizontal path of flow, rather than up-flow, helps prevent sludge carry-over. The coagulated water from the reactors pass into a storage tank from which it is pumped through a battery of eight pressure filters, 11 ft. 0 in. diam. The filtered water continues under pressure through a battery of three cation units, 11 ft. 0 in. diam., and then into a vacuum deaerator for the removal of the carbon dioxide and oxygen. From there it is pumped through a battery of three anion units, 11 ft. 0 in. diam. to service.

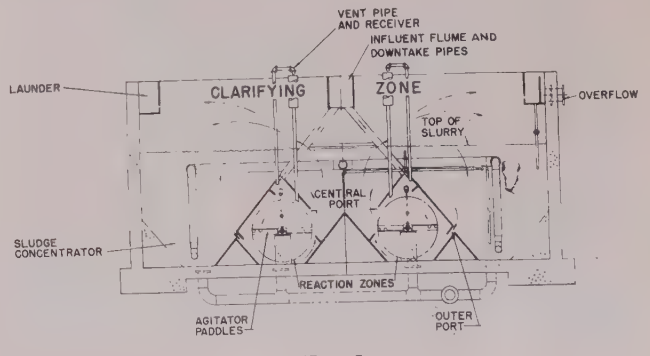


Fig. 5

The operation of the demineralizer is entirely automatic. Instead of a valve nest of Saunders valves with the multiplicity of pneumatic tubing involved, a Cochrane hydromatic single control valve is provided on each cation and anion unit. These hydromatic valves have cast iron bodies, but are entirely rubber lined on the inside to withstand the acid water. Inside the body are six diaphragm valves, hydraulically operated by a small motor-driven pilot valve mounted on the front of the valve. A 16-watt motor operates the pilot valve which in turn automatically open and close the correct internal diaphragm valves required for the operation of the unit. All the cation and anion units will be regenerated once a day at full load.

The regeneration system will employ sulfuric acid and 25% liquid caustic soda. The regenerants will flow into measuring tanks from which submerged vertical centrifugal pumps will pump the necessary quantity of regenerant into mixing tees where the strong regenerant is diluted in line, as shown.

In order to reduce the amount of caustic soda, a caustic reclaiming tank is provided to recover a part of the caustic soda from the previous regeneration to be used as the first step of the following regeneration before injecting the new caustic. As the chemical operating results, Table VII, indicate, when caustic reclaiming is used the silica in the effluent will be slightly higher than when all fresh caustic is employed. This is due to the fact that the reclaimed caustic contains some silica from the previous regeneration. During present low pressure boiler operations, the use of the caustic reclaiming tank will be justified because the slightly increased silica will still be very low for that boiler pressure. However, when the future high pressure boilers are installed, then the lower silica will be produced by omitting the reclaiming step.

The instrumentation provided will be: (1) recording orifice meters on each of the cation and anion units; (2) effluent conductivity indicators on the three anion units; (3) a recording flowmeter and recording conductivity meter on the final common outlet, with a contactor to close an outlet valve ahead of storage, if effluent conductivity rises excessively; (4) conductivity solubridge indicators on the regenerant system to indicate strength of diluted regenerant and rotameters to indicate flow rates of regenerant and dilution water.

A vacuum de-aerator was chosen instead of the usual decarbonator because: (1) it reduces dissolved oxygen, thereby avoiding oxidation of anion resin, as well as corrosion of treated water pipe lines; (2) it avoids contamination of the water by atmospheric dust, which may take place if a decarbonator with an air blower introduces air into the water. Such dust has fouled anion resin. The vacuum deaerator which extracts the gases by steam jet ejectors will thus avoid the introducing of any dust laden air.

The guaranteed results are: (1) turbidity from the reactors not to exceed 10 p.p.m.; (2) soluble silica in the demineralized effluent to be 0.05 p.p.m. with 100% fresh caustic, or 0.1 p.p.m. when using reclaimed caustic; (3) total ionized soluble solids 2 p.p.m.; (4) conductivity 10 mmhos, or 100,000 ohms resistance; (5) dissolved oxygen 0.1 p.p.m.

This quality of effluent will be entirely suitable for the future 1900-p.s.i. boilers. This will be a very large and modern demineralizer, fully automatic and containing the latest design features that have been developed for proper control of demineralization. One of these features is the use of flat bottoms for all the cation and anion units, reinforced by steel beams welded on the outside to withstand internal pressure. These flat bottoms permit omitting the usual anthracite subfill to support the resin. Such subfills, particularly for the anion resin, cause long rinsing to wash out the excess caustic used in regeneration. The underdrains, consist of a header across the diameter of the tank with laterals at right angles so as to have absolutely even spacing of orifices in these laterals. This insures uniform collection and distribution of water to prevent channeling and premature breakthrough of impurities. Thus the utmost purity of final effluent is obtained at all times. The laterals are covered by screening to prevent escape of resin. Omission of subfill not only saves rinse water and regenerating time but avoids the danger of escape of resin through the bottom because of upset anthracite beds.

CONCLUSIONS

Three methods of water treatment for boiler feed purposes have been described in this paper: (1) hot lime zeolite, (2) sodium zeolite and desilicizer, and (3) clarification and demineralization.

Each of these three methods has its application for particular water conditions, boiler pressure, and effluent quality requirements. The selection of one of these methods must depend on a study of investment and operating cost, as well as effluent quality, as illustrated from the experiences of three modern rapidly growing paper and pulp mills described in this paper.

Hot lime zeolite has the advantage of greater versatility to handle variable water compositions, particularly waters that are not clear. It is favored for medium boiler pressures under 1000 p.s.i. because of low operating cost.

Sodium zeolite and desilicizer is a cold process plant, usually less expensive to install and will reduce the silica in the effluent to 0.5 p.p.m. or lower. It has the advantage of eliminating the use of acid in the regeneration so that no rubber-lined shells and piping and valves are required. It is economical, particularly in cases where sodium zeolite softeners are already in use at the plant so that the anion salt splitter desilicizer units can be easily added. Simplicity of operation is one of its main advantages.

The demineralizer produces the best quality of effluent, lowest in total solids, alkalinity, and silica. However, only clear water must be passed through demineralizers to protect the resin from fouling. Therefore, a modern pretreatment clarification plant must always be included where the raw water is of surface origin. The trend is definitely toward demineralization when boiler pressures exceed 1000 p.s.i.

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Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N.Y., Feb. 23–26, 1959.

Pressurized High Consistency Screening in the Pulp Mill

RAY H. CROSS

PRESSURIZED screening has come a long way since its inception at the Shartle Div. of The Black-Clawson Co. over 18 years ago. The original pilot model was constructed of standard steel pipe and called the Selectifier® screen.

During the years that followed, considerable experimentation was carried on both in the laboratory and in various mills. A wealth of experience in the application of pressure screening was being compiled.

Various design changes were made with perhaps the most significant being the patented noncontacting airfoil bars used in the rotating element. This and other developments helped increase the acceptance of the screen to the extent that

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now there are well over 1300 of these screens operating in pulp and paper mills throughout the world.

The performance was excellent as a machine screen. The screens not only produced good screening, but deflocculated fiber bundles thereby improving formation, protected against wire damage caused by tramp material and relieved foaming conditions with pressurized operation.

It was soon realized that these were characteristics that had been sought for some time in pulp mill screens. There had been several instances that involved attempts of testing modifications of conventional centrifugal screens prior to washing. All of them had met with relatively little success.

Nevertheless, the need for a good pressurized pulp mill screen still existed. One can readily see that there are a number of advantages to be realized from this type of application. The Selectifier screen produces quality screening not only in conventional applications, such as those in a groundwood mill or on washed chemical stocks, but its pressurized construction permits effective usage prior to washing.

An application of this type permits hot brown stock screening which heretofore has been considered very desirable but not possible, primarily because of foam conditions. Efficient removal of shives and other foreign material at this point permits better over-all pulp mill operation.

In high yield mills such as those producing kraft linerboards, effective use can be made of a pressurized disk refiner to reduce the screen bleed-off to acceptable size for subsequent rescreening. This segregated dispersal of the foreign material facilitates better washing with more recovered salt cake. The screening action itself also provides for better washing as it insures a more uniform mat formation on the washers. A press roll can be used without fear of damage to the facing cloth, since detrimental, oversized materials are eliminated.

In mills producing higher grade pulps that are to be bleached, the circulation, or bleed-off material can be passed through secondary screening for gallonage reduction as well as screening, and then disposed of in several ways which will be discussed later.

Before further discussion of what has been done to date and the types of installations that are possible, it would be well to examine the construction of a particular pressurized pulp mill screen, and its adaptability to meet specific conditions.

The Selectifier screen as shown in Fig. 1, is a vertical, totally enclosed rotary screen which operates completely full of stock and under pressure at all times. The main body castings incorporate the inlet, discharge, and reject openings, as well as fittings to receive the stationary perforated screen cylinder and drive mountings. The spiral bevel drive which is recommended for all pulp mill applications, is bolted directly to the underside of the screen. It is directly coupled to the drive motor and the output shaft extends through a seal box into the central portion of the screen. The noncontacting airfoil bar rotating element is mounted on the extended shaft. The bars and studs of the rotating element are bolted to the center or rotor cage to allow adjustment for proper clearance between the airfoil bars, and the screen cylinder.

The entire unit, including the drive motor is mounted on the base which can be placed almost anywhere since no special foundation is required. Piping flexibility is obtained since the inlet and discharge sections can be rotated independently of each other in almost any of the 30° increments allowed by the bolt spacings.

To expose the interior of the screen, it is necessary to only remove the nuts holding the cover in place, and lift the cover by turning the handwheel on top. The cover can then be swung to one side.

Figure 2 shows the interior of the screen with a stationary cylinder and the rotating element in place. The reject volute trough in the bottom can also be seen in this figure.

The stock enters the 12-in. tangential inlet at the top, passes downward and outward through the screen plate, and discharges through a 12-in. outlet on the outside of the cylindrical housing.

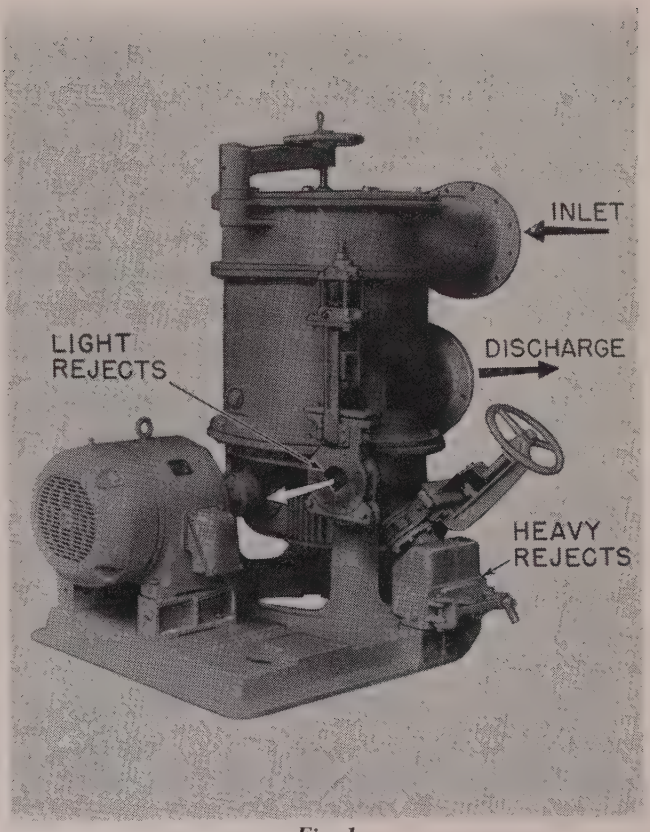


Fig. 1

Rejected material, or material which will not pass through the cylinder perforations is continuously forced downward into the reject volute. Extremely heavy materials such as metals and the like, pass through an opening in the bottom of the volute into the heavy trash box.

Lighter material such as shives, large fiber bundles, and in-

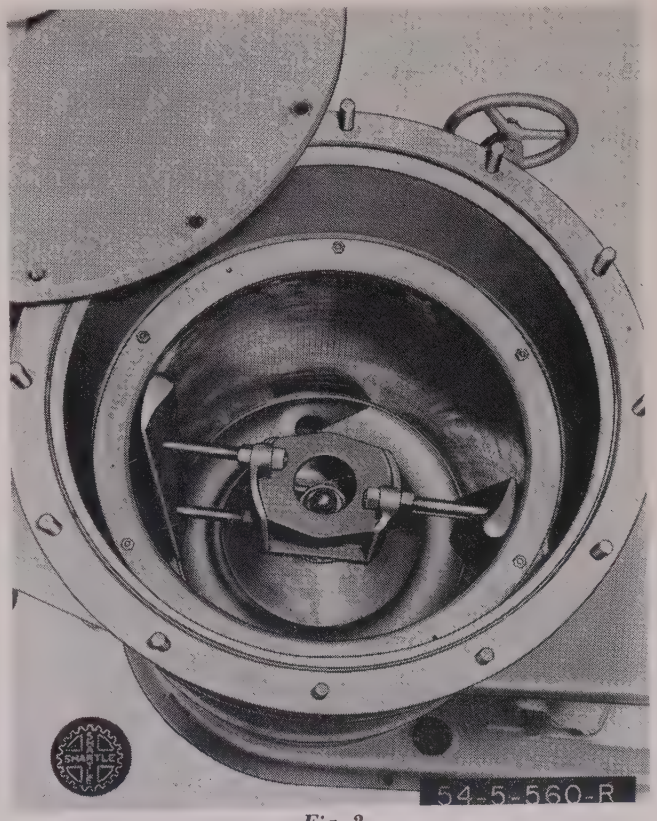


Fig. 2

completely cooked pieces of wood continue past this opening into a 4-in. diam. reject volute end. This reject end is fitted with a 4-in. flanged connection to which is attached a V-notch slide valve. This valve is held partly open to maintain a constant continuous bleed-off. This can be a handwheel valve, or it can be pneumatically operated.

Several factors can be varied; namely, the materials of construction, the diameter of the screen cylinder perforations, the speed of the rotating element, and the method and amount of reject removal. A brief examination of these factors will permit a better understanding of why considerable interest has developed in pressurized screening.

The main body parts whose interior portions come in contact with the stock can be cast iron, anti-acid bronze, or type 316 stainless steel. When made of cast iron, all interior parts are coated with an epoxy resin formulation for cleanliness purposes.

The diameter of the screen cylinder perforations can be varied to meet specific requirements. It has been found that round holes, as opposed to slots, can and will remove most of the objectionable material. For a given set of conditions, the ratio of the foreign material removed by a screen to that entering is basically a direct proportion. It is expected that better screening can be obtained only at the expense of having a lower tonnage passed through the screen. Conversely, for the same conditions, higher tonnage can be passed only at the expense of poorer screening efficiency. One thing encountered in screening slick, unwashed stock is that smaller hole sizes must be used to obtain reject removal equivalent to that of conventional screening.

The rotating element turning at high speeds acts as a mixer and performs the function of pulsing the fluid mixture at the screen plate surface to prevent the fibers from matting and plugging the holes in the cylinder. The design of the air-foil bar is such that it creates a negative pressure at the trailing edge. As this passes a hole it pulses and pulls fibers and reject material away from the face of the screen. The strength and frequency of the pulsing vary with the speed of rotation. It has been determined in commercial applications that 400 r.p.m. in the 24-in. diam. screen is sufficient for most pulp mill applications. In some applications involving very long fibers, say 3 mm. and over, using high consistency and larger hole sizes, it may be necessary to use higher speeds to prevent excessive thickening and matting at the perforations.

The amount of rejected material and the method of removal can be varied to best suit the operating conditions and results desired. Continuous bleed-off is always recommended for pulp mill applications. The amount of bleed-off is dependent upon the grade or degree of cook, and the desired appearance of the end product, with a higher bleed-off obviously removing higher percentage of foreign material. This can be varied by changing the size opening in the V-notch slide valve. In the more difficult applications or sometimes in those that are previously untried, the reject valve may be automated with a periodically purging pneumatic cylinder to effect better removal of coarse material.

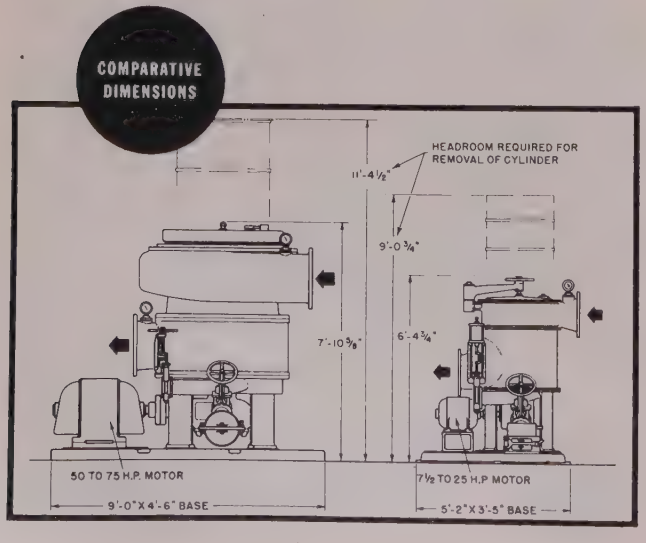


Fig. 3

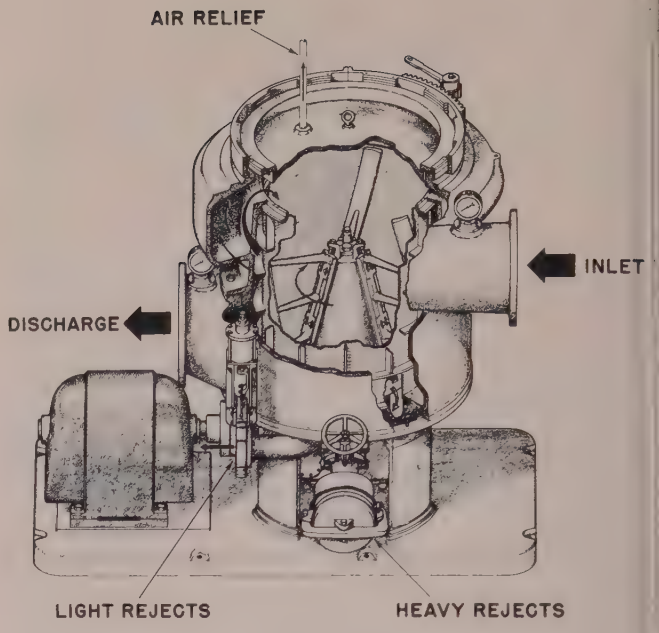


Fig. 4

So far, the discussion has only considered the smaller 24-P size which has a basket 24 in. diam. by 24 in. high. More recently a larger, higher capacity screen was developed and designated the 36-P. As can be seen in Fig. 3 it has the same over-all appearance and design characteristics as its smaller connterpart. Figure 4 shows the interior of the 36-P. The screening cylinder is 36 in. diam., and 42 in. high, and it has a capacity of about three times that of the 24-in. screen.

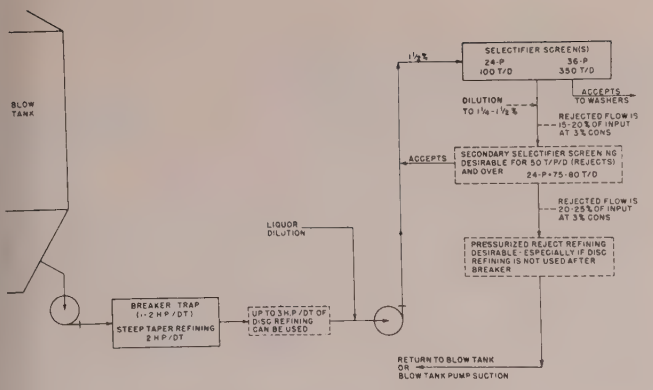
Since these pressurized screens can be operated at up to 75 p.s.i. inlet pressure, installation problems are minimized. The only requirement is that the inlet pressure be high enough to allow for an average pressure drop of 2 to 4 p.s.i. across the screen cylinder, plus any subsequent head requirements beyond the screen.

Extensive experience has been gained from installations made on several representative grades of pulp; namely, kraft, neutral sulfite, and groundwood.

Excellent results have been obtained in a southern linerboard mill with pressurized Selectifier screens operating ahead of brown stock washers on softwood kraft pulps. The screens are preceded by steep taper refiners which consume $1\frac{1}{2}$ to 2 hp. per daily ton. By performing good screening at this point in the system, and eliminating the necessity of having conventional screens after washing, subsequent deckers, and related equipment can be iliminated. This installation was somewhat revolutionary in pulp mill screening as it was the first to be successfully operated under pressure at this point, and in the presence of strong black liquor.

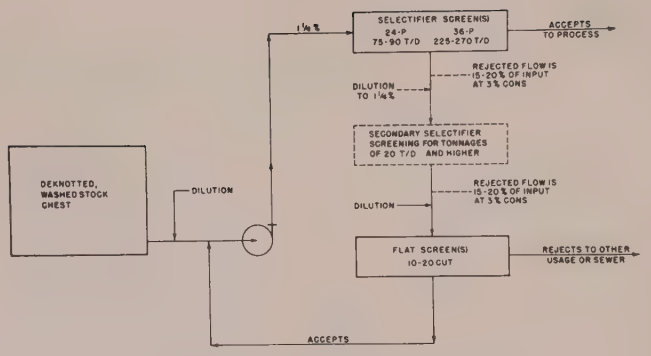
Further experience has been gained from a similar application at another mill producing kraft linerboard. Screened tonnages of good quality, and I emphasize good quality, ranged to in excess of 350 tons per day through one 36-in. screen. It is realistic to expect that this will be bettered with more operation. This installation was also ahead of brown stock washers.

Pressurized Selectifier screens have also been proved in a northern mill operating on pulp produced from hardwoods by the neutral sulfite method. In this case, the screens are


BLOW TANK
SELECTIFIER SCREEN(S)
24-P 100 T/D
36-P 350 T/D
ACCEPTS TO WASHERS
DILUTION TO 1¼-1½%
REJECTED FLOW IS 15-20% OF INPUT AT 3% CONS
ACCEPTS
SECONDARY SELECTIFIER SCREEN NG DESIRABLE FOR 50 T/P/D (REJECTS) AND OVER
24-P-75-80 T/D
REJECTED FLOW IS 20-25% OF INPUT AT 3% CONS
LIQUOR DILUTION
PRESSURIZED REJECT REFINING DESIRABLE - ESPECIALLY IF DISC REFINING IS NOT USED AFTER BREAKER
BREAKER TRAP (1-2 HP/DT) STEEP TAPER REFINING 2 HP/DT
UP TO 3 HP/DT OF DISC REFINING CAN BE USED
RETURN TO BLOW TANK OR BLOW TANK PUMP SUCTION

SCREENING OF UNBLEACHED KRAFT LINERBOARD GRADES

Fig. 5


1½%
SELECTIFIER SCREEN(S)
24-P 75-90 T/D
36-P 225-270 T/D
ACCEPTS TO PROCESS
REJECTED FLOW IS 15-20% OF INPUT AT 3% CONS
DILUTION TO 1¼%
SECONDARY SELECTIFIER SCREENING FOR TONNAGES OF 20 T/D AND HIGHER
DEKNOTTED, WASHED STOCK CHEST
DILUTION
REJECTED FLOW IS 15-20% OF INPUT AT 3% CONS
FLAT SCREEN(S) 10-20 GUT
REJECTS TO OTHER USAGE OR SEWER
ACCEPTS

SCREENING OF BLEACHABLE KRAFT AND SULPHITE (AFTER WASHING)

Fig. 7

preceded by disk refiners, and followed with two-stage washing. Cooking is carried out at a moderately high yield, and the pulp is subsequently bleached for usage in a line of high-grade printing and converting papers. From this experience, it is felt that such screens could give excellent results on other grades of neutral sulfite pulp, as well as other systems involving chemical softening and mechanical fiberizing of hardwoods, such as the new cold soda systems.

Still another installation has been made in a northern mill on news grade groundwood pulp. This was the first successful usage of a screen operating under pressure in this type of pulp mill. Both the 24-in. and 36-in. screens have undergone extensive testing at this mill, which together cover a span of over 3 years. Throughput, quality, and ease of operation have been found to be very favorable.

The majority of us are undoubtedly most concerned with application data, and the recommended sequence of equipment for a particular type of pulp. This is represented in Figs. 5 through 9 which depict the following typical screening layouts: (1) unbleached kraft linerboard grade, prior to washing; (2) bleaching grade kraft, prior to washing; (3) bleaching grade kraft and sulfite after washing; (4) groundwood grades; and (5) various chemical-mechanical systems prior to washing.

All tonnages shown on these figures are accepted stock tonnages per screen, while maintaining good quality. Any screen can put through what appears to be a tremendously high tonnage but this is usually only at the expense of good quality.

Figure 5 depicts our present thinking on unbleached kraft linerboard grades with pressurized screens located ahead of the brown stock washers. A breaker trap or steep paper refiner will properly condition the knots and other oversize material so that effective screening can be carried out. As indicated pressurized of hot stock disk refining can be used to advantage, but is not necessary for good screen operation. If employed, a maximum of about 3 hp. per daily ton is recommended, since much more than this will cause an excessive freeness drop, resulting in an inefficient washer operation.

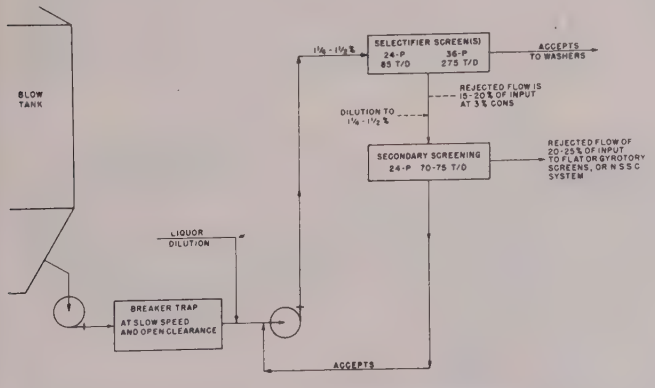
It has been found that a bleed-off of 15 to 20% of the flow to the primaries is desirable for best operation. In large tonnage applications where there are 50 tons per day and over of rejected flow from the primary screens, secondary screening is recommended. This is not necessary for good screening but is primarily aimed at concentrating the flow of rejected material and reducing the gallonage to a pressurized disc refiner.

This separate refining operation on the rejects is especially effective, and is desirable for best over-all operation. The higher circulation of 20 to 25% from the secondary screen is in order since there is a higher concentration of rejects present.

The thickening of the rejected flow to 3% is very desirable for subsequent refining. This system purposely does not show an automatic consistency regulator as there is a considerable sensing delay or lag, due to the necessity of a large calming section prior to the regulator. It has been found to be more satisfactory to use a second pump as shown, with dilution liquor added at the suction for good mixing and manual control.

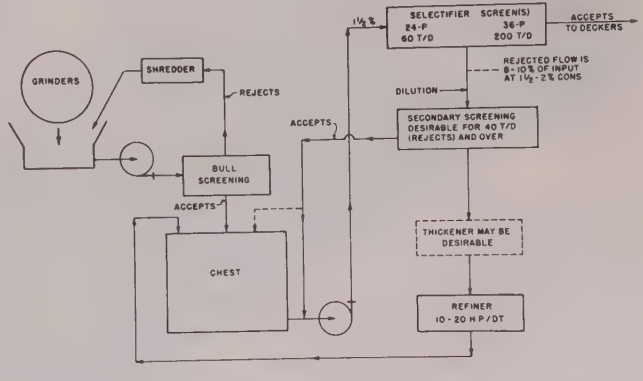
Figure 6 illustrates our thinking on brown stock screening of bleaching grade kraft pulp. There are some who feel it is detrimental to use the system shown for high-grade pulps, as it is suspected that there is an excessive dispersal of foreign material. We do not find this to be the case, and believe the breaker trap is an excellent machine for this application. An 18-in. machine operating at a low power usage of $^3/_4$ to $1^1/_2$ hp. per daily ton, and an open clearance of $^1/_8$ in. between the stator and rotor, and a relatively low speed of 900 r.p.m. will give the gentle dispersing action desirable for subsequent good screening. This is possible without an undue increase in the load on centrifugal cleaners.

The arrangement differs from that of a higher yield system in that refining is not used and the rejected flow from the


BLOW TANK
1¼-1½%
SELECTIFIER SCREEN(S)
24-P 85 T/D
36-P 275 T/D
ACCEPTS TO WASHERS
REJECTED FLOW IS 15-20% OF INPUT AT 3% CONS
DILUTION TO 1¼-1½%
SECONDARY SCREENING 24-P 70-75 T/D
REJECTED FLOW OF 20-25% OF INPUT TO FLAT OR GYROTORY SCREENS, OR N S S C SYSTEM
LIQUOR DILUTION
BREAKER TRAP AT SLOW SPEED AND OPEN CLEARANCE
ACCEPTS

SCREENING OF BLEACHABLE KRAFT FOR FOODBOARD AND HIGH GRADE PAPERS

Fig. 6



SCREENING OF GROUNDWOOD FOR NEWS AND SIMILAR GRADES

Fig. 8

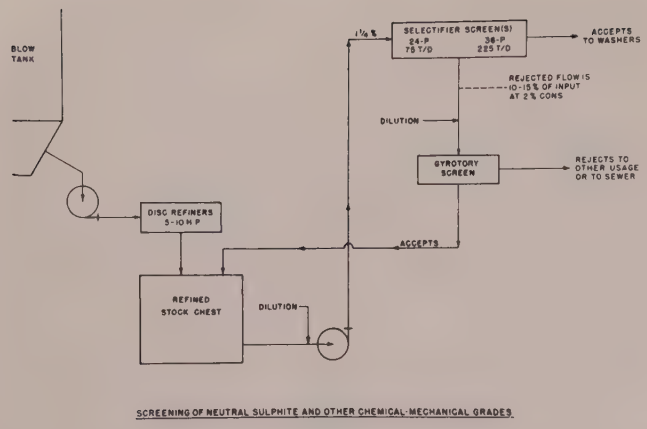


Fig. 9

secondary screen is removed to either flat or gyratory screening, or sent to another system such as 9 pt. if possible.

Figure 7 shows a layout using Selectifier screens on washed kraft and sulfite pulps. Typical conditions or ranges are shown but it should be realized that there is flexibility and that alternatives are quite possible. We believe with the intimate action between the airfoil bars and the screening cylinder, that we can use smaller hole sizes than most present applications for better screening. Although the benefits of screening before washing are not realized here, this type of installation lends itself to many advantages and savings, as will be summarized later.

Figure 8 depicts a typical arrangement of Selectifier screens on groundwood pulp. From our experience in this field we are quite certain that excellent screening can be done with proper sequence and sizing of equipment. If has been found that the bull screens should have holes small enough to remove the majority of large shives and other coarse material coming to the screens from the grinder room. The Selectifiers are capable of continual operation at $1^1/_2\%$ consistency which is much higher than is normal with previous methods. From this one can realize the tremendous saving in deckering requirements. It is even more favorable since there are no internal showers to lower consistency.

Figure 9 shows a screening layout in a neutral sulfite mill. This could also be fairly standard for various other grades of pulps which are chemically softened and followed by a mechanical fiberizing action as shown in the layout. Normally, mixed hardwoods are used for these pulps but there can be exceptions. Even though fairly small screen hole sizes are dictated by relatively short fibers, note that the accepted stock tonnages are surprisingly high. Efficient separation of acceptable pulp and coarse material at this point, with further treatment and/or removal of the latter is particularly advantageous at this point in a system.

In all of these installations we are advocating 25 hp. on the 24-in. unit, and 75 hp. on the 36-in. screen, and find that about 80 to 90% of this is consumed. Speeds of the rotating airfoil bar element are usually 400 r.p.m. on the 24-in. unit, and 267 r.p.m. on the larger screen which gives the same peripheral speed and pulse frequency when using two and three airfoils respectively. Exceptions such as increased speeds, may have to be made on extremely long fibers, such as Douglas-fir.

In closing, a listing is made of the advantages of pressurized screening, in particular those of the Selectifier, not necessarily in the order of their importance: (1) it is already proved in several representative installations; (2) it consumes only about one-half as much horsepower per daily ton as other screens now used on washed stock; (3) pressurized screens are neat and compact with low installation costs; (4) higher consistency operation is possible at the inlet and without the use of internal shower water; (5) they help provide for better formation of the mat on the washers resulting in better and more efficient washing; (6) on most applications involving deckers, thickening requirements are greatly reduced with less deckering and related equipment necessary; and (7) pressurized screening is possible with equaled or bettered rates and quality throughout.

Based on the progress made to date, we feel certain that a trend has been initiated with this new concept of pulp mill screening.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 23–26, 1959.

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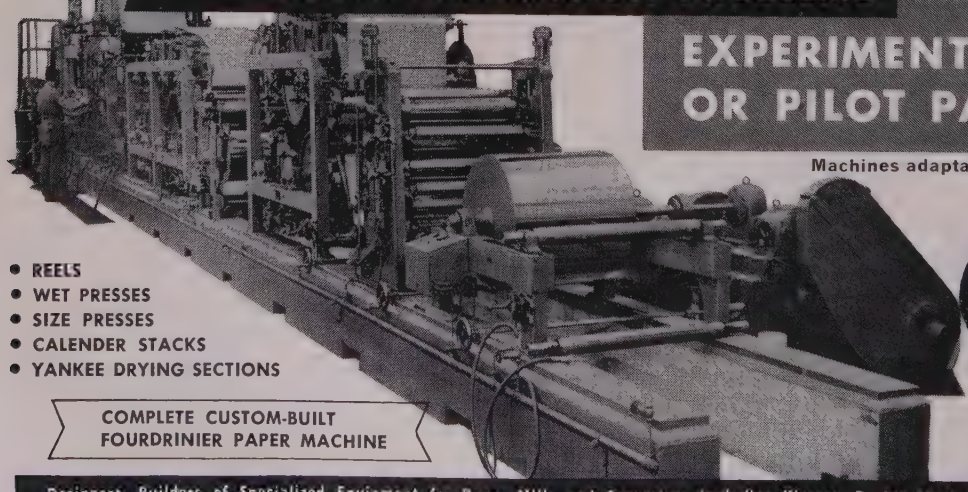

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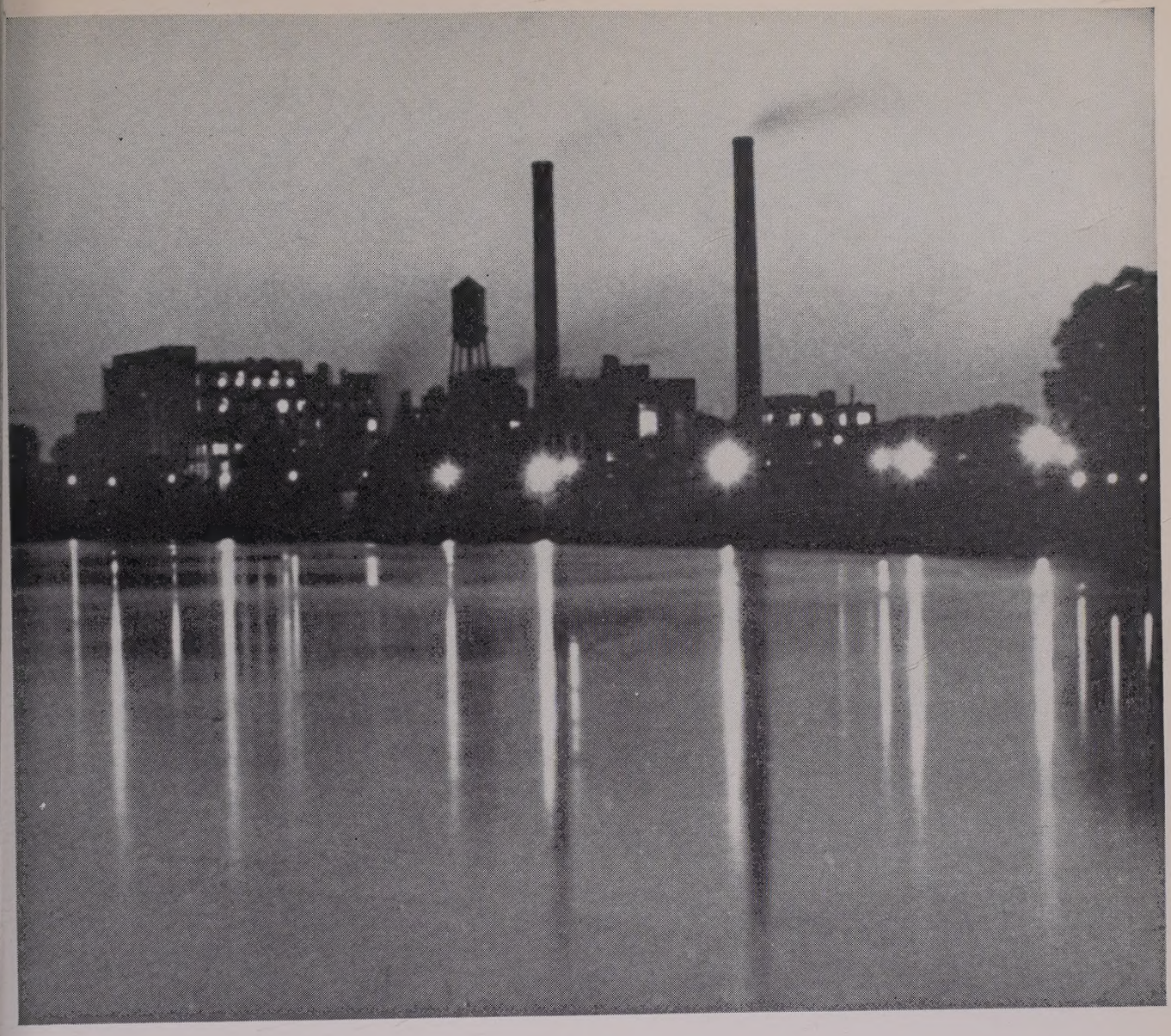

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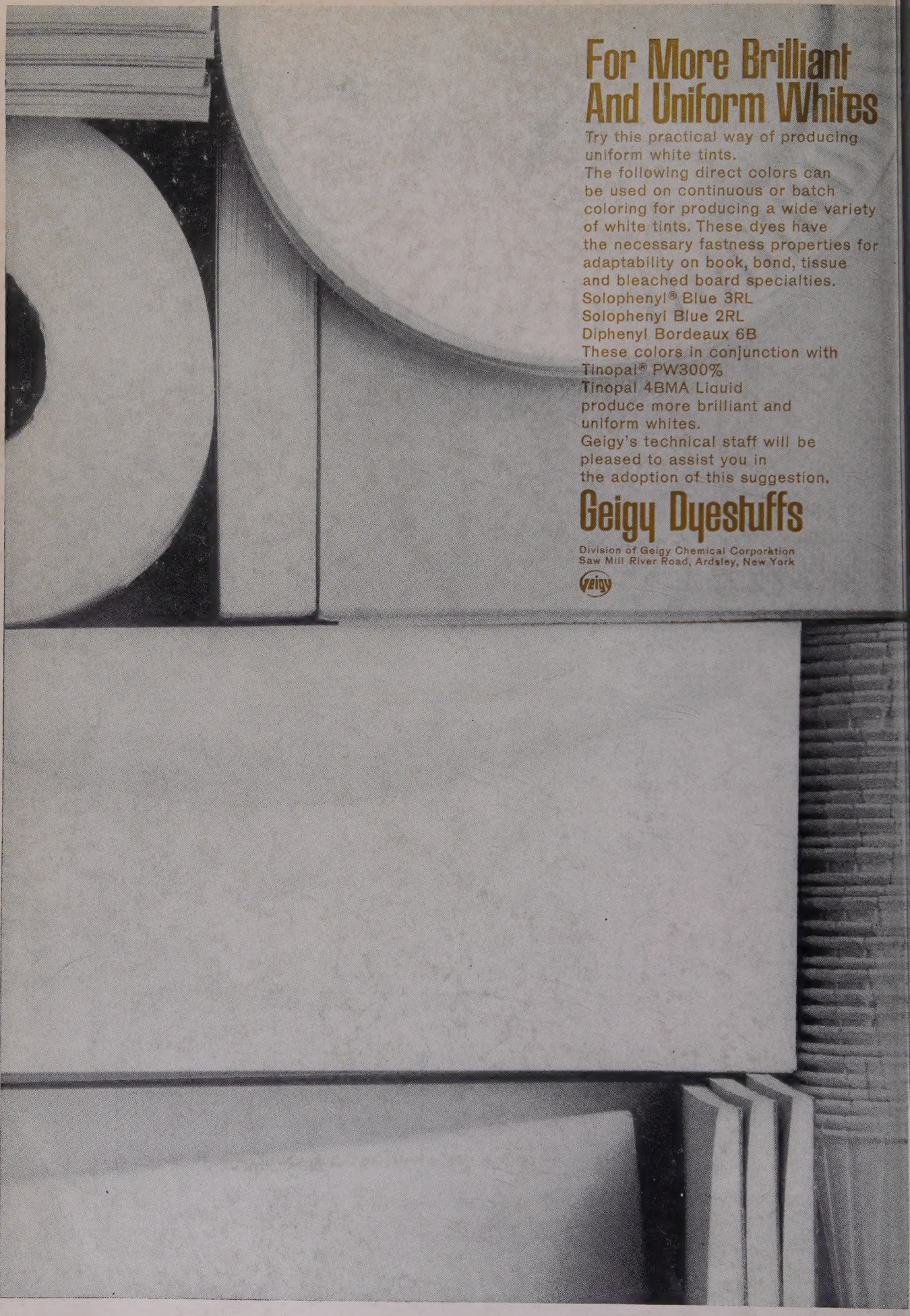

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